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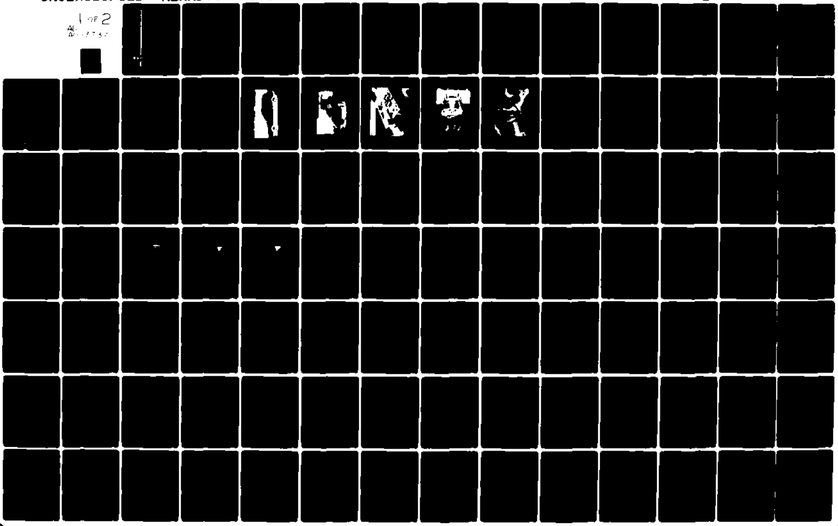

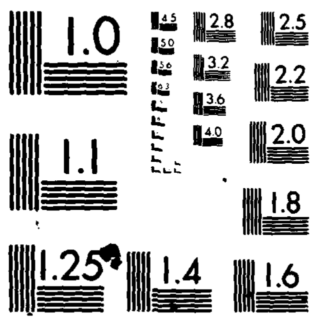

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Report 2308

BASELINE TESTS OF THE GE-100 CENTENNIAL ELECTRIC PASSENGER VEHICLE

by
Edward J. Dowgiallo, Jr.
Ivan R. Snellings
and
William H. Blake

September 1980

U.S. ARMY MOBILITY EQUIPMENT
RESEARCH AND DEVELOPMENT COMMAND
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The GE-100 Centennial electric vehicle is a one-of-a-kind prototype. Results of performance tests, speed, acceleration, gradeability, range, and efficiencies are presented. The GE-100 is powered by eighteen 6-volt lead-acid batteries driving a 16.3-kW d.c. series motor through an EV-1C controller. The motor drives the wheels through a chain drive to the differential. No regenerative braking was provided.

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PREFACE

The Electric and Hybrid Vehicle Test was conducted by the US Army Mobility Equipment Research and Development Command (MERADCOM) under the guidance of the US Department of Energy (DOE).

Michael E. Johnson, P.E. of VSE Corporation was responsible for aspects of calibration of the signal conditioning circuits and recording instruments as well as data tabulations, plotting, and preparation of the report. Richard Boyd of VSE Corporation was responsible for aspects of the report and data analysis.

Computer programming and some data tabulations and plots were made by David Scott and Arthur Nickless of the Systems Technology & Management Division, Management Information Systems Directorate, MERADCOM.

James A. Queen and Calvin T. Bushrod of the Environmental & Field Division, Product Assurance & Testing Directorate, assisted in vehicle operation and data collection.

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I. SUMMARY

The GE-100 Centennial Electric, an electric vehicle manufactured by General Electric and Triad Services, Inc., was tested under the direction of the U.S. Army Mobility Equipment Research and Development Command (MERADCOM) from 4 June to 20 June and from 2 July to 27 July 1979. The tests are part of a Department of Energy (DOE) project to access advances in electric vehicle design. This report presents the performance test results on the GE-100 Centennial Electric.

The GE-100 Centennial Vehicle is a one-of-a-kind experimental prototype. The concept was developed by GE and Triad Services, Inc., under DOE contract EY-76-C-03-1294, phase one of the Near-Term Electric Vehicle Program. The conceptual study explored electric vehicle performance available with standard production components. The vehicle was built and funded by General Electric, using available hardware, i.e., standard production components. It is powered by eighteen 6-volt lead-acid traction batteries driving a 16.3-kW (21.8-hp) (3200-r/min) motor through an EV-1C armature chopper and control. All items are 1978 or earlier technology. Front brakes are inboard Chevelle with copper drums; rear brakes are Subaru drums. The vehicle did not employ regenerative braking.

The vehicle was provided by General Electric. The intent of testing was not to verify vehicle performance, as this prototype is not a candidate for the DOE demonstration programs. However, the available standard production components used in this vehicle will be used in prospective vehicles. The testing was performed to expose the electric-hybrid-vehicle (EHV) community to the results available with 1978 electrical technology.

The results of the tests are shown in Table 1.

Table 1. Summary of Test Results for

Date (July)	Test Speed or Driving Pattern	Range	Number of Cycles	Energy Out of Battery	Battery Energy Economy*	Energy Out of Charger (Into Battery)	Batt Effici
13	40 km/h (25 mi/h)	112 km (70 mi)	-	15.5 kWh	$.138 \frac{kWh}{km}$ $\left(.221 \frac{kWh}{mi}\right)$	27.8 kWh	55.8
18	56 km/h (35 mi/h)	96 km (60 mi)		15.3 kWh	$.159 \frac{kWh}{km}$ $\left(.255 \frac{kWh}{mi}\right)$	26.0 kWh	56.3
12	80 km/h (50 mi/h)	69 km (43 mi)	-	12.9 kWh	$.187 \frac{kWh}{km}$ $\left(.300 \frac{kWh}{mi}\right)$	21.6 kWh	59.7%
6	SAE J227a B	80 km (50 mi)	227	16.3 kWh	$.204 \frac{kWh}{km}$ $\left(.326 \frac{kWh}{mi}\right)$	29.7 kWh	54.9%
10	SAE J227a C	67 km (42 mi)	122	14.4 kWh	$.215 \frac{kWh}{km}$ $\left(.343 \frac{kWh}{mi}\right)$	25.0 kWh	57.6%
24	SAE J227a D	62 km (39 mi)	42	14.1 kWh	$.227 \frac{kWh}{km}$ $\left(.362 \frac{kWh}{mi}\right)$	20.5 kWh	68.8%

* Battery Energy Economy = Energy out of battery per mile of range.

lts for GE Centennial Electric Vehicle

Battery Efficiency	Energy into Charger	Charger Efficiency	Vehicle Energy Economy	Wind Start of Test	Wind End of Test	Temperature Start of Test	Temperature End of Test
55.8%	33 kWh	84.3%	$.295 \frac{kWh}{km}$ $\left(.471 \frac{kWh}{mi}\right)$	Calm	South 7.4 km/h (4.6 mi/h)	23°C (74°F)	30°C (86°F)
56.3%	31 kWh	83.4%	$.517 \frac{kWh}{km}$ $\left(.323 \frac{kWh}{mi}\right)$	Calm	NW 9.3 km/h (5.8 mi/h)	26°C (79°F)	27°C (81°F)
59.7%	27 kWh	80.2%	$.391 \frac{kWh}{km}$ $\left(.628 \frac{kWh}{mi}\right)$	Calm	Calm	22°C (72°F)	26°C (78°F)
54.9%	37 kWh	80.3%	$.463 \frac{kWh}{km}$ $\left(.740 \frac{kWh}{mi}\right)$	Calm	NW 3.7 km/h (2.3 mi/h)	16°C (61°F)	27°C (80°F)
57.6%	30 kWh	83.3%	$.448 \frac{kWh}{km}$ $\left(.714 \frac{kWh}{mi}\right)$	NW 3.7 km/h (2.3 mi/h)	South 7.4 km/h (4.6 mi/h)	26°C (78°F)	25°C (77°F)
68.8%	25 kWh	82.0%	$.403 \frac{kWh}{km}$ $\left(.641 \frac{kWh}{mi}\right)$	Calm	SW 4.8 km/h (3 mi/h)	26°C (78°F)	29°C (85°F)

II. INTRODUCTION

The vehicle tested and the data presented in this report are in support of Public Law 94-413 enacted by Congress on 17 September 1976. The law requires the Department of Energy (DOE) to develop data characterizing the state-of-the-art with respect to electric and hybrid vehicles. The data so developed are to serve as a baseline to compare improvements in electric- and hybrid-vehicle technologies, to assist in establishing performance standards for electric and hybrid vehicles, and to help guide future research and development activities.

The U.S. Army Mobility Equipment Research and Development Command (MERADCOM) under the direction of the Electric and Hybrid Research, Development, and Demonstration Office; Division of Transportation Energy Conservation; DOE, has conducted track tests of electric vehicles to measure their performance characteristics and vehicle component efficiencies. The tests were conducted using a DOE test procedure "ERDA-EHV-TEP," described in Appendix A of MERADCOM Report 2244.[1] This procedure uses the "Electric Vehicle Test Procedure SAE J227a," revised February 1976. U.S. customary units were used in the collection and reduction of data. The units were converted to the International System of Units for presentation in this report. U.S. customary units are presented in parentheses. Number values are truncated to reflect nominal values except where precision is required. Conversion factors are shown in Table 2.

The assistance and cooperation of General Electric Industrial Control Division and Corporate Research and Development were greatly appreciated. The Department of Energy supplied funding support and guidance during this project.

III. OBJECTIVES

The characteristics of interest for the GE-100 Centennial Vehicle are vehicle speed, range at constant speed, range when operated in a selected driving pattern, maximum acceleration, gradeability, gradeability limit, road energy consumption, road power, and vehicle energy economy.

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[1] E. J. Dowgiallo, Jr.; C. E. Bailey, Jr.; I. R. Snellings; and W. H. Blake; "Baseline Tests of the EVA Metro Electric Passenger Vehicle," MERADCOM Report 2244 (July 1978).

Table 2. Conversion Factors

Quantity	To Convert from	to	Multiply by
Acceleration	ft/s^2	m/s^2	3.048×10^{-1}
	mi/h.s	m/s^2	$4.470\,4 \times 10^{-1}$
Energy (work)	ft · lbf	J	1.355 818
	Wh	Btu	$3.412\,141 \times 10^{3}$
	Wh	J	3.600×10^{3}
	Btu (IT)	J	1.055 056
Force	lbf	N	4.448 222
Length	ft	m	3.048×10^{-1}
	mi	km	1.609 344
Mass	lb	kg	$4.535\,924 \times 10^{-1}$
Power	hp (550 ft · lbf/s)	W	$7.456\,999 \times 10^{2}$
Velocity	mi/h	km/h	1.609 344
Pressure	lbf/in^2	kPa	6.895

IV. TEST VEHICLE DESCRIPTION

1. Description. The GE-100 Centennial Vehicle is the Near-Term Reference Electric Vehicle. It is a 3-door, 4-passenger commuter car driven by 18 6-volt lead-acid batteries. It was designed from the ground up as an electric vehicle. Design features worthy of noting are the reduced aerodynamic drag, rear facing passenger seats, mechanical transmission replaced by electrical controls, batteries removable as a single unit from the ventilated tunnel, side doors open parallel to the body, and the use of selected materials for weight reduction. The vehicle is shown in Figures 1 through 5. The vehicle is described in Appendix A.

2. Operating Characteristics. The vehicle is similar to a comparable-size internal-combustion vehicle. Controls are located in similar positions and the driving characteristics are similar. A key switch is required to activate the vehicle. The "accelerator" pedal controls a signal voltage to the EV-1C controller which, in turn, programs the pulse width (on time) and pulse frequency of battery voltage connected to the 16.2-kW (21.8-hp) (3200-r/min) motor. The controller reacts to the "accelerator" position to control the vehicle speed and acceleration as controlled by the driver. A relay bypasses the controller for high-power or high-speed conditions. The controller employs field weakening to increase top speed. Reversing is accomplished electrically, but the operator actions are similar to those for a vehicle with an automatic transmission. No regenerative braking is provided on this vehicle. A block diagram is shown in Figure 6.

V. INSTRUMENTATION

The GE Centennial was instrumented to measure vehicle speed and range, battery voltage, current, averaged current, instantaneous power and averaged power, motor voltage, the temperature of the motor frame, and the battery charger power. Battery electrolyte temperatures were measured with thermometers. A brief description of the instrumentation system is given in the following paragraphs. Details of the recorder are given in Appendix D of MERADCOM Report 2244.[2]

Instrumentation consisted of signal-conditioning circuits and a magnetic tape recorder for recording analog signals of electrical parameters. The magnetic tape recorder was operated in the frequency modulation mode at 4.763 cm (1-7/8 in.) per second. The signal-conditioning circuitry to the recorder consisted of a main battery voltage divider, a shunt-voltage amplifier for current monitor, an analog multiplier, and circuits for averaging power and current.

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[2] E. J. Dowgiallo, Jr.; C. E. Bailey, Jr.; I. R. Snellings; and W. H. Blake; "Baseline Tests of the EVA Metro Electric Passenger Vehicle," MERADCOM Report 2244 (July 1978).

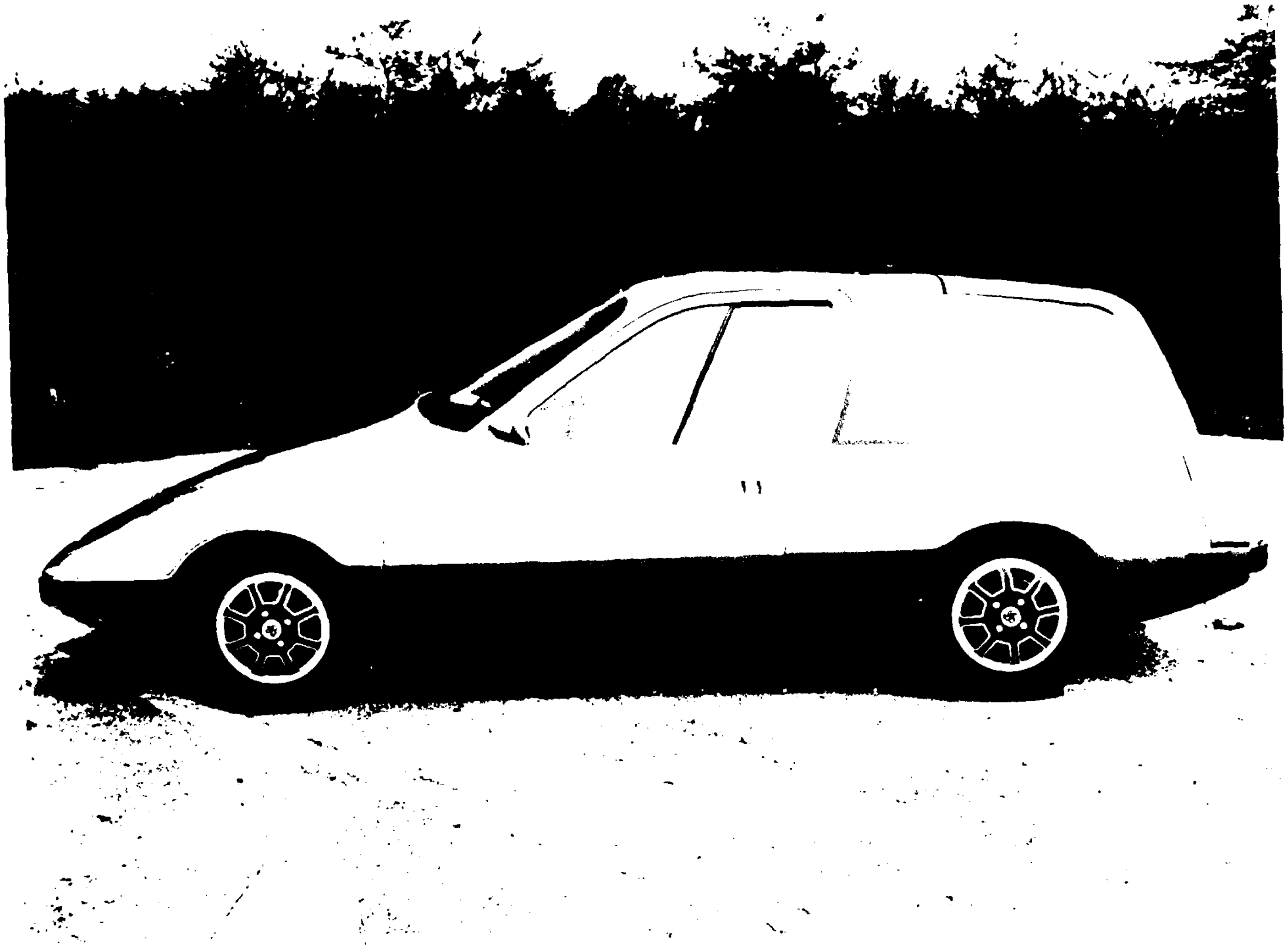

Figure 1. Side view of GE-100 Centennial Vehicle.

Figure 2. Front/left side view of GE-100 with all doors open.

Figure 3. Front view of GE-100 showing SCR controller and gasoline-fired heater and motor.

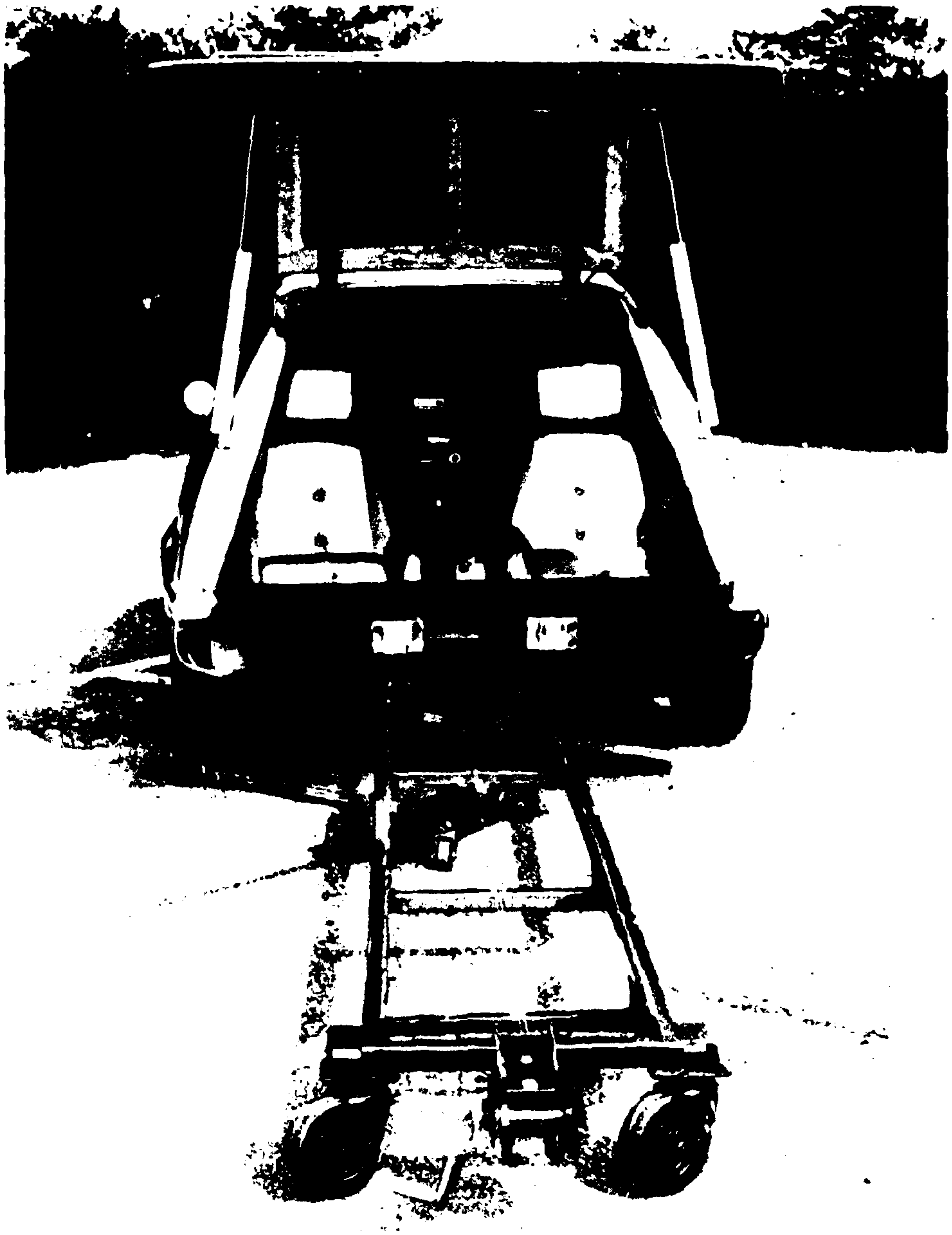

Figure 4. Rear view of GE-100 showing battery removal apparatus.

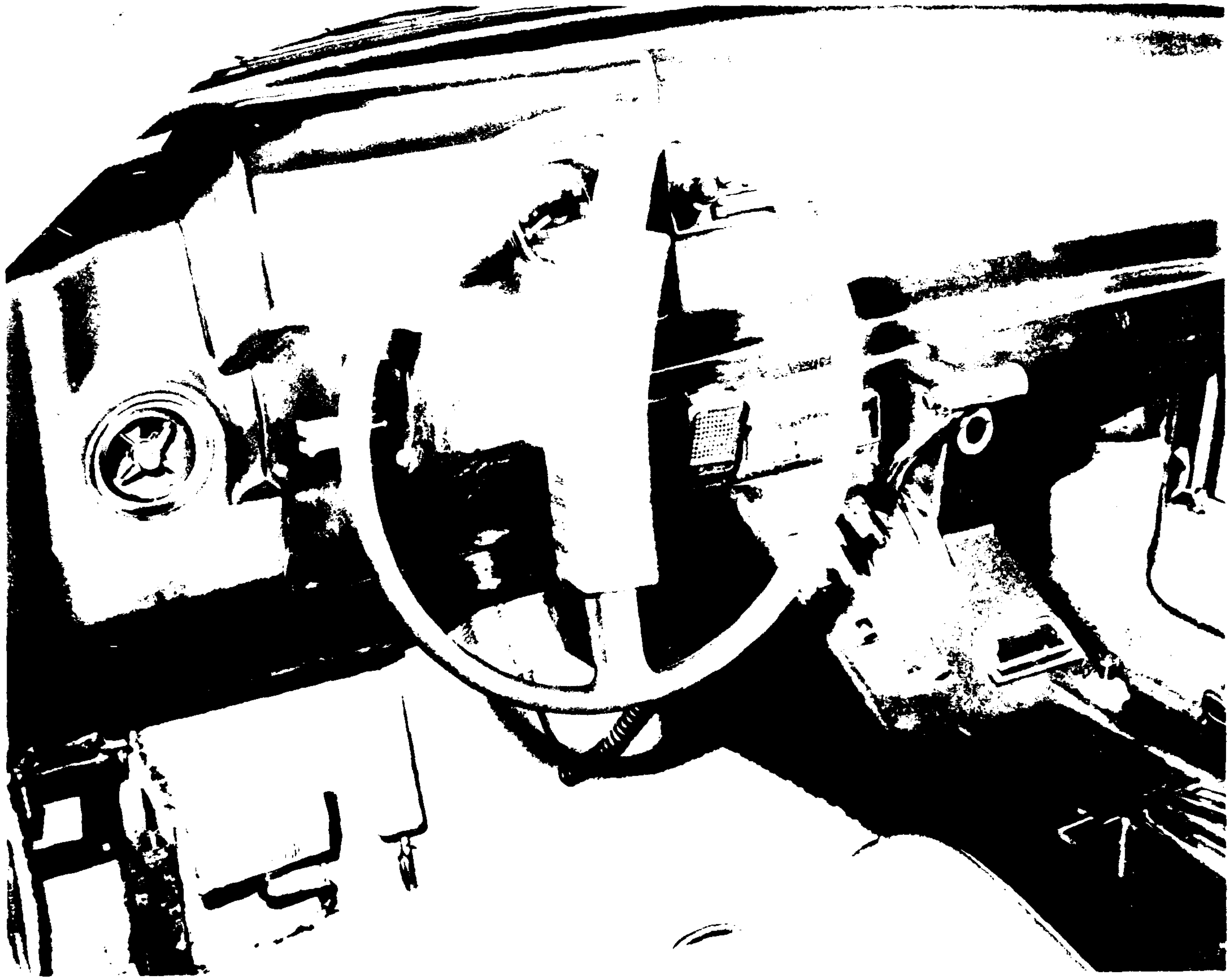

Figure 5. Inside view from driver's seat of GE-100.

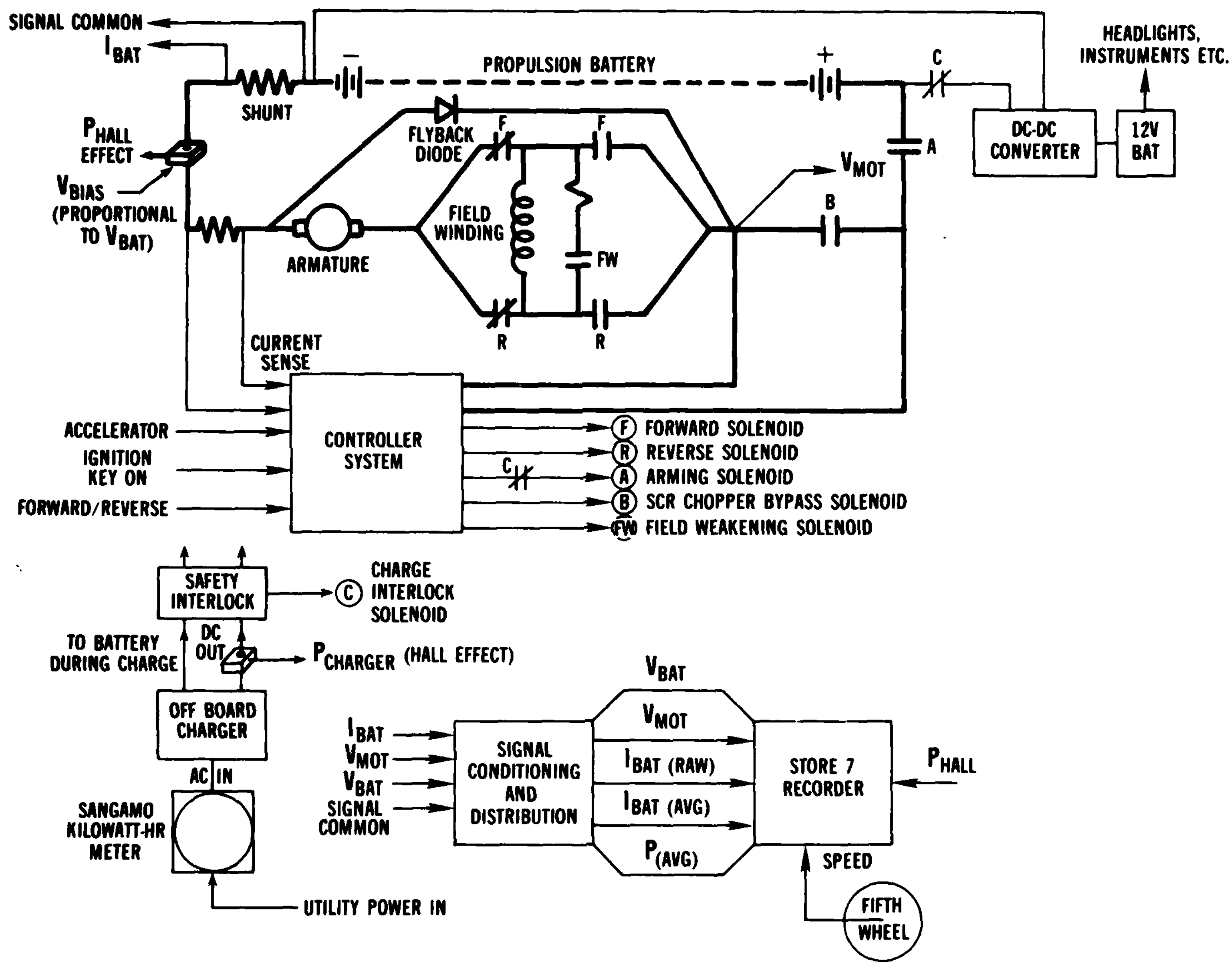

Figure 6. Block diagram of propulsion system and instrumentation.

A voltage proportional to power was produced by the instantaneous multiplication of voltage and current. Current and power were recorded both raw and electronically averaged. The raw values include the rapid switching transients associated with the solid-state controller.

VI. TEST PROCEDURES

The tests were performed at the MERADCOM test facility, Fort Belvoir, and at the Aberdeen Proving Ground (APG) test facility at Aberdeen, Maryland. When the vehicle was delivered to MERADCOM, the pretest checks described in Appendix F of MERADCOM Report 2244[3] were conducted. A shakedown run was performed to familiarize the driver with the operating characteristics of the vehicle and to verify proper operation of all instrumentation systems. All tests were run in accordance with the DOE Electric and Hybrid Vehicle Test and Evaluation procedure, Appendix A of MERADCOM Report 2244.[4] All tests were performed with a full load of 227 kg (500 lb).

1. Maximum Cruise Speed. The vehicle was capable of sustaining 88 km/h (55 mi/h) on level straightaway. The MERADCOM facility has a 2.0-km (1¼-mi) loop with a 3-percent and a 5-percent grade. The vehicle could sustain 80 km/h (50 mi/h) but not 88 km/h on this course. The highest speed used for the constant-speed range test was 80 km/h. The vehicle was operated to a maximum speed of 97 km/h (60.3 mi/h) on a level track (± 1-percent grade) at Aberdeen Proving Ground.

2. Range Tests — Constant Speed. Range tests at constant speed were carried out at 40 km/h (25 mi/h), 56 km/h (35 mi/h), and 80 km/h (50 mi/h); speeds were held constant within 1.6 km/h (1 mi/h), and the test was terminated when the vehicle could no longer maintain 95 percent of the designated test speed. Range at 40 km/h was 112 km (70 mi). Range at 56 km/h was 96 km (60 mi). Range at 80 km/h was 69 km (43 mi).

3. Range When Operated in a Selected Driving Pattern. Test Schedules "B," 32 km/h (20 mi/h); "C," 48 km/h (30 mi/h); and "D," 72 km/h (45 mi/h) of SAE J227a were run. Range on the "B" schedule was 80 km (50 mi). Range on the "C" schedule was 67 km (42 mi). Range on the "D" schedule was 62 km (39 mi).

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[3] E. J. Dowgiallo, Jr.; C. E. Bailey, Jr.; I. R. Snellings; and W. H. Blake: "Baseline Tests of the EVA Metro Electric Passenger Vehicle," MERADCOM Report 2244 (July 1978).

[4] *Ibid.*

4. Maximum Acceleration. Maximum acceleration was calculated from the recorded time and velocity data. The tests were conducted on the 3-mile straightaway at APG. Time to accelerate to 32 km/h (20 mi/h) was 4.5 s and to 50 km/h (31 mi/h) was 8.5 s. Gradeability at speed was calculated from the acceleration data and from draw-bar tests. To ensure the passenger comfort with a smooth start, the controller delays maximum torque until the vehicle begins to roll.

5. Coast-Down Tests. The vehicle coasted to a stop from the maximum speed reached during the acceleration test. The velocity was recorded on an analog recorder. The analog recording was analyzed for the SAE J227a vehicle road energy consumption and vehicle road load power. The unique design feature of coupling the motor directly to the drive train did not allow mechanical isolation.

6. Tractive Force Tests. The maximum-grade capability of the test vehicle was determined from tractive force tests by towing a field dynamometer at approximately 1.6 km/h (1 mi/h) while the test vehicle was being driven with wide-open throttle. The force was measured by the dynamometer instrumentation from a load cell attached between the vehicles. The test was run with the batteries 0 percent, 40 percent, and 80 percent discharged. This test was used to compute the gradeability limit. Gradeability was a function of controller action rather than battery discharge, at least up to 80-percent depth of discharge (DOD). Tractive tests were terminated at 80-percent DOD as determined by measurement of energy with a Hall-effect watt-hour meter. A DOD was achieved by operating the vehicle at 56 km/h (35 mi/h).

7. Charger Efficiency Tests. A residential kilowatt-hour meter was used to measure input energy to the charger. The charger output power and energy were measured with a Hall-effect watt-hour meter which responds to inputs from d.c. to considerably higher than 5 kHz. Charger efficiency was calculated as the ratio of energy to the battery, as measured by a Hall sensor, to the energy to the charger as measured by a rotating watt-hour meter. The efficiency was calculated to be in the range of 80 percent to 84.3 percent. The ferro-resonant transformer corrected for changes in the line voltage and was programmed for 27.5-amp peak current demand, with the charge rate tapering off based on battery voltage. A complete test was not performed on the charger characteristics. The auxiliary battery was charged from the on board charger by a d.c. to d.c. converter from the propulsion batteries during vehicle operation.

VII. TEST RESULTS AND DISCUSSION

The data collected from all range tests are summarized in Table 1. The table shows the test data, type of test, environmental conditions, the range test results, energy into and out of the battery, and the energy into the charger. These data are used to determine vehicle range, energy economy, and efficiencies.

1. Maximum Speed. The maximum speed of the vehicle was measured during the acceleration coast down tests. It is defined as the maximum speed that could be reached on the track under full power. The measured maximum speed was 97 km/h (60.3 mi/h) for this vehicle.

2. Range. The following range tests were run: 40-km/h (25-mi/h), 56-km/h (35-mi/h), 70-km/h (44-mi/h), 80-km/h (50-mi/h), B-cycle, C-cycle, and D-cycle. The test results are shown in Table 1. These tests were run one time each due to the limited availability of the vehicle. The speed, velocity, current, and power profiles for the third cycle and next to the last cycle for each "B," "C," and "D" driving schedule are presented in Figures 7 through 18. The data for these figures are shown in Appendix B.

3. Maximum Acceleration. The average maximum acceleration of the vehicle was measured with the batteries fully charged, 40 percent discharged, and 80 percent discharged. The results of the tests are shown in Figure 19 and Appendix B. Maximum observed acceleration was 10.14 km/h.s (6.3 mi/h.s) at 4.8 km/h (3.0 mi/h). Velocity as a function of time is shown in Figures 20, 21, and 22 for the 0-percent, 40-percent, and 80-percent depths of discharge of the battery, respectively. Note that the first-cycle (0 percent DOD) acceleration has some initial anomolous behavior which is reflected in the other derived graphs of road energy and road power. This initial cycle problem probably arises from vehicle lubricant stiffness and controller considerations. The jagged appearance of the graphs is due to road and vehicle irregularities: the impact becomes pronounced as velocity and acceleration flatten. Selection of the cycles representing 40-percent and 80-percent DOD was affected by track considerations.

4. Gradeability. The grade in percent which the vehicle is able to traverse at any selected speed is calculated from maximum acceleration tests by using the equation:

$$G = 100 \tan (\sin^{-1} 0.0455\ \bar{a}_n)\ \%$$

where:

a_n = acceleration in miles per hour per second at speed n.

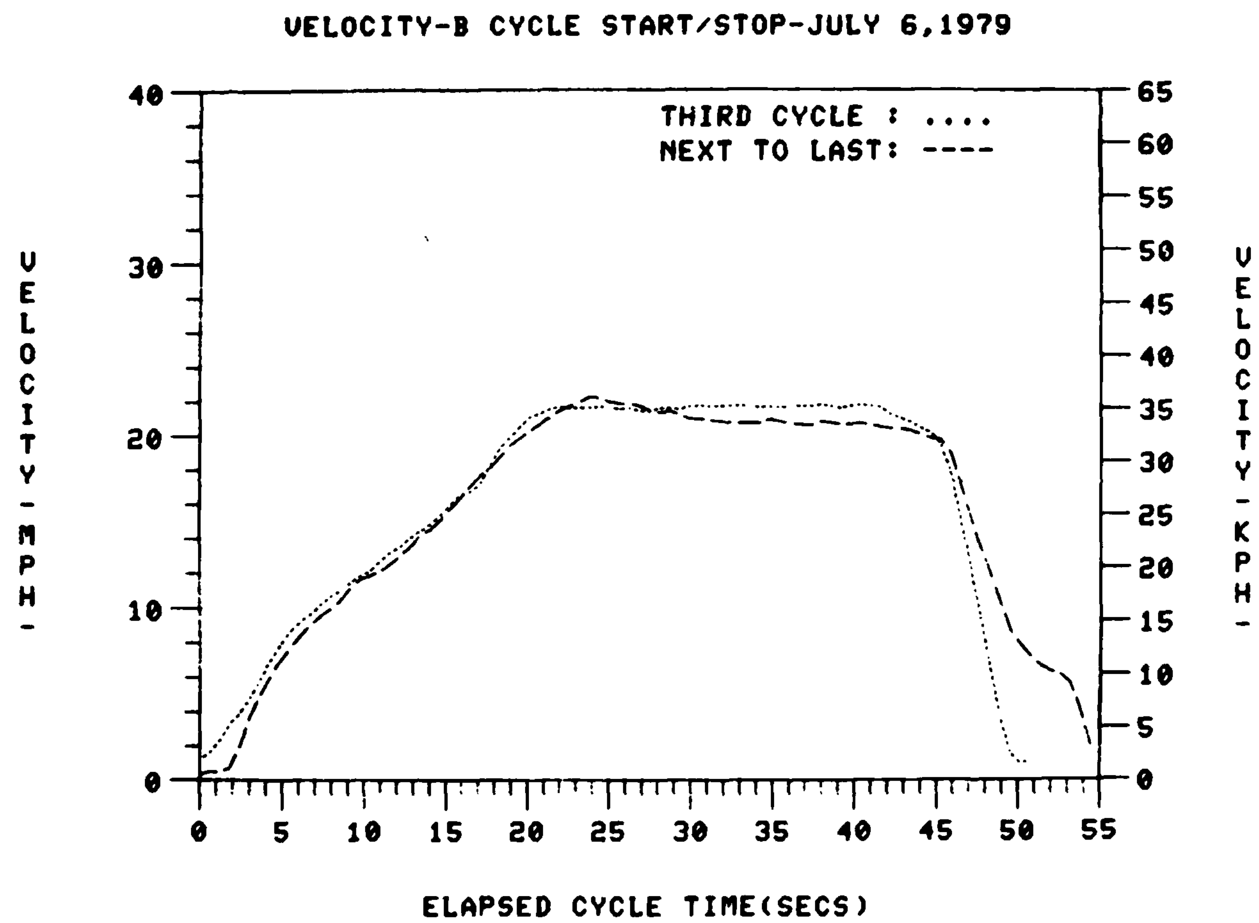

Figure 7. "B" Cycle, velocity vs time.

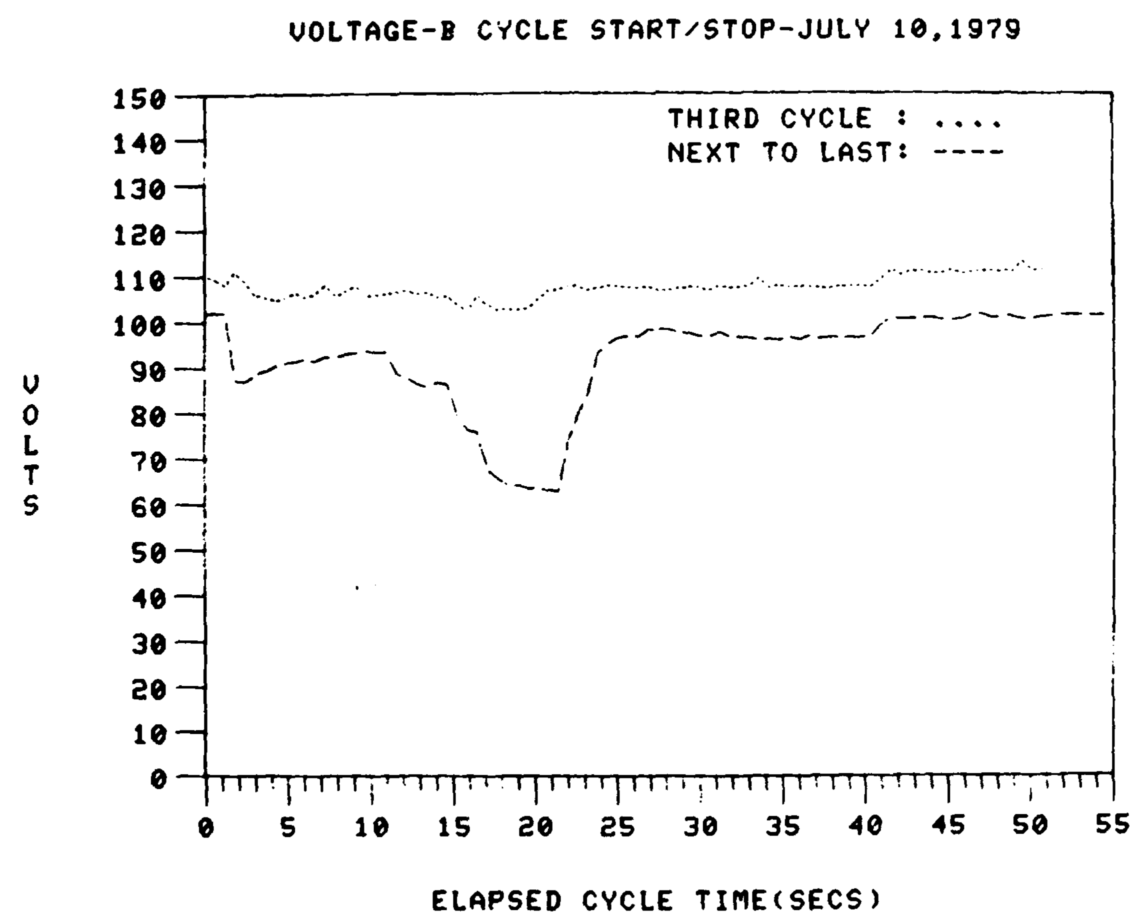

Figure 8. "B" Cycle, battery voltage vs time.

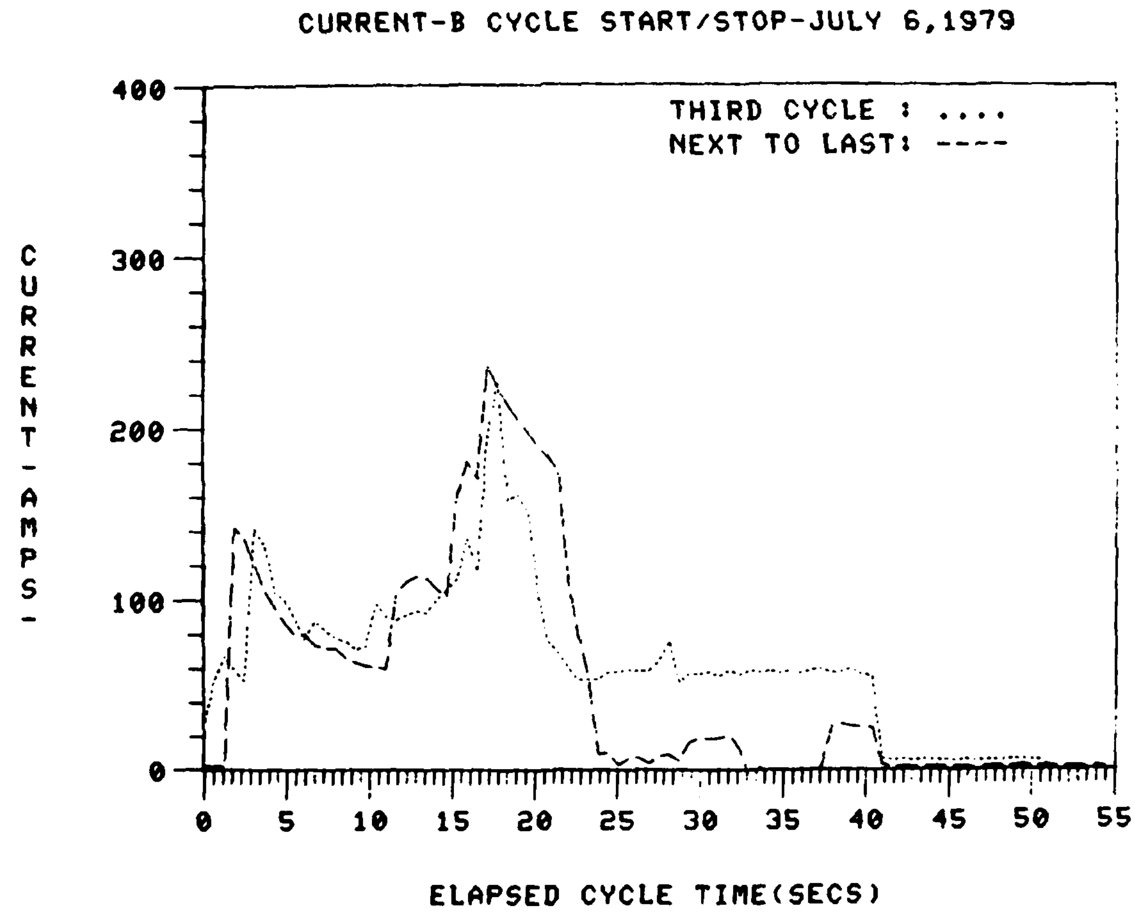

Figure 9. "B" Cycle, battery current vs time.

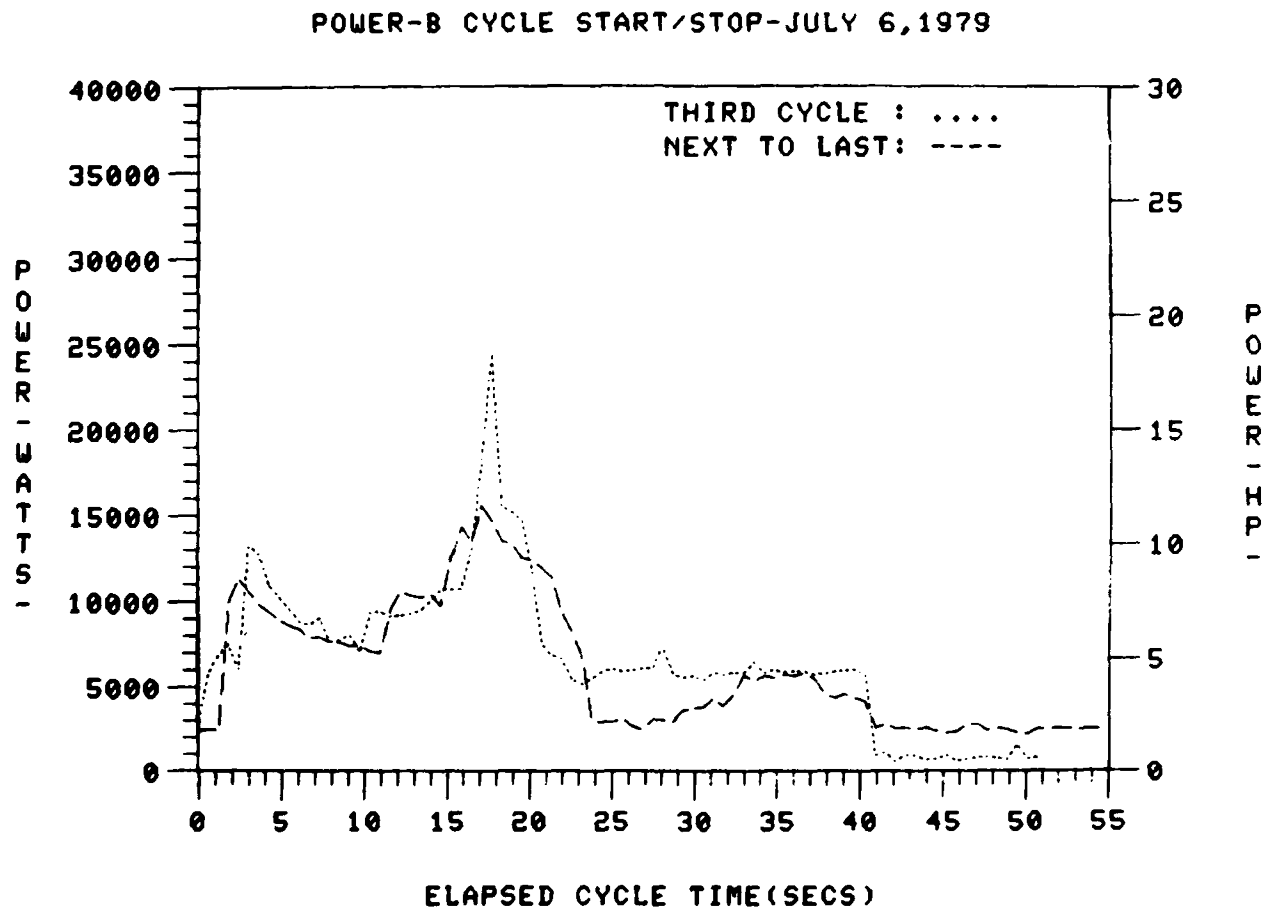

Figure 10. "B" Cycle, battery power vs time.

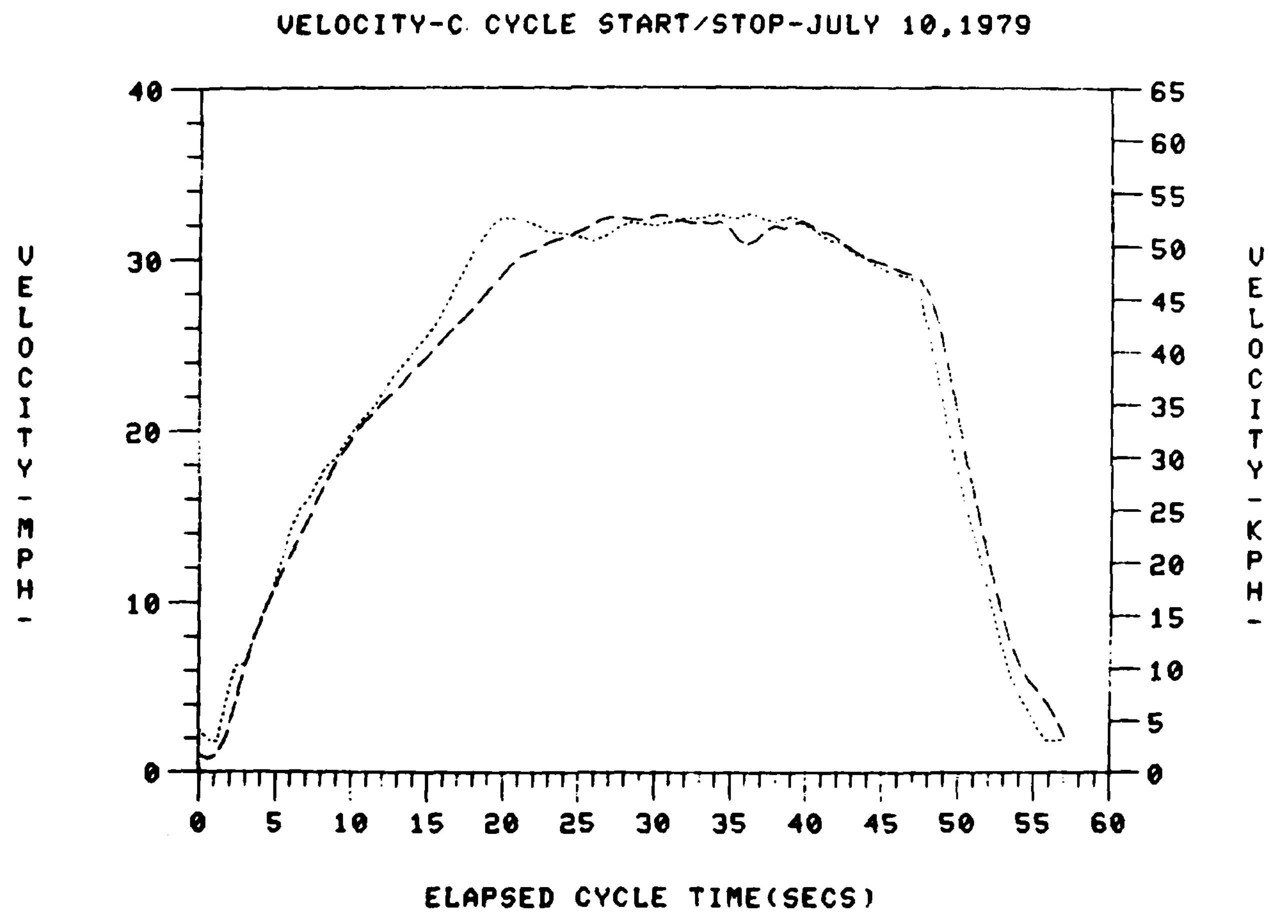

Figure 11. "C" Cycle, velocity vs time.

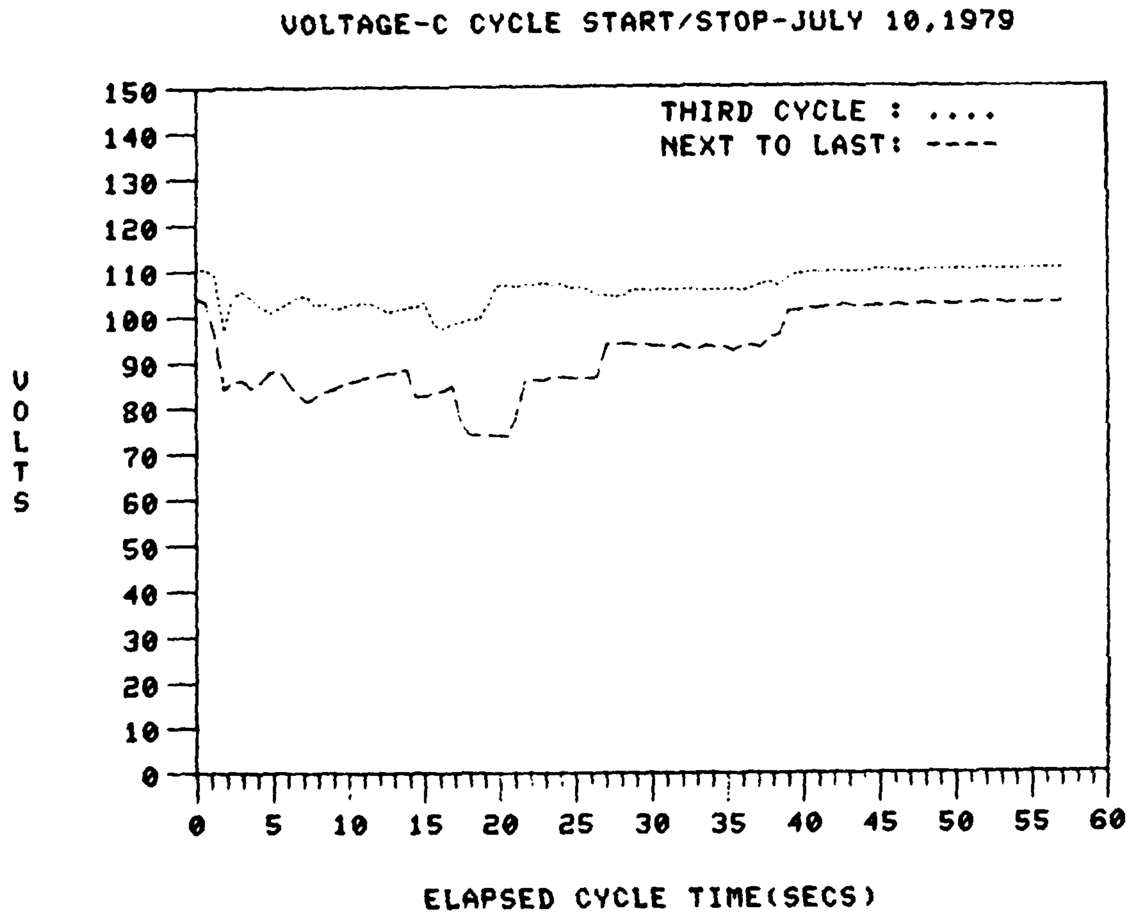

Figure 12. "C" Cycle, battery voltage vs time.

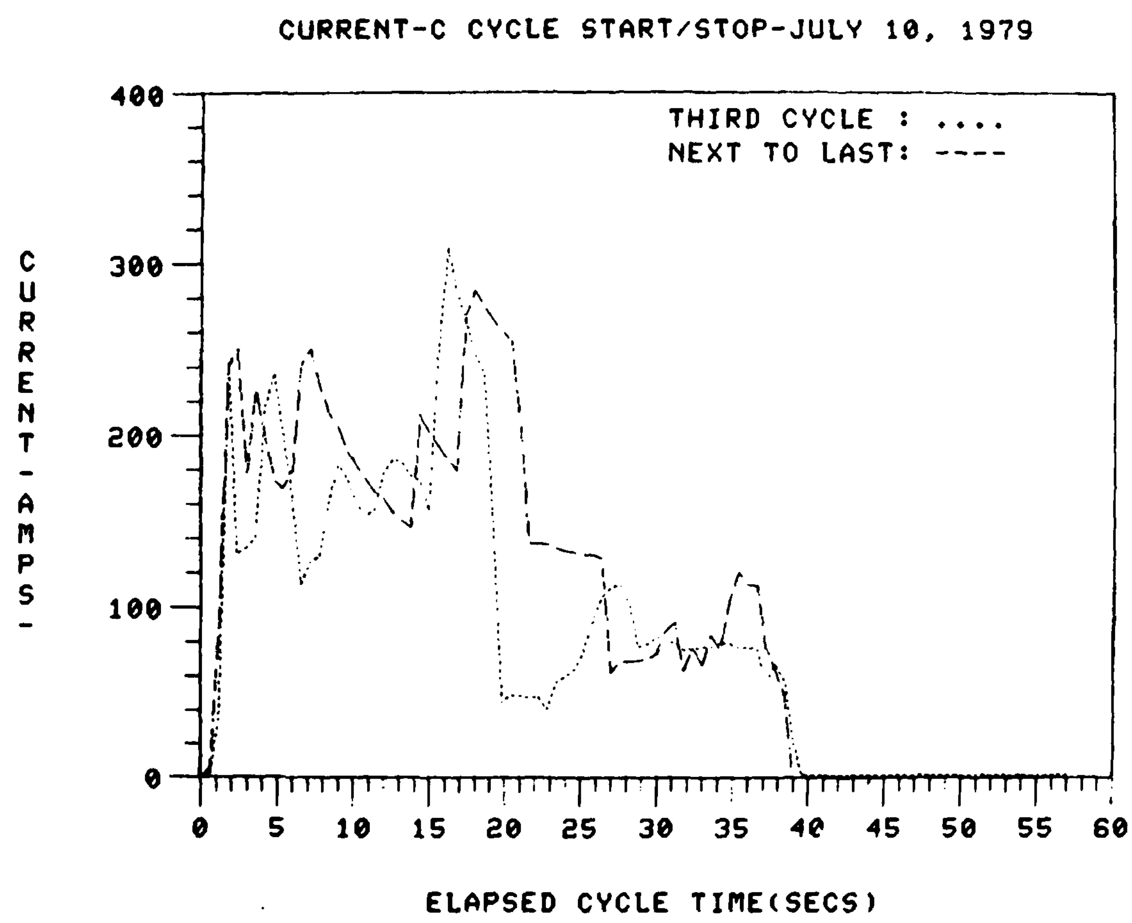

Figure 13. "C" Cycle, battery current vs time.

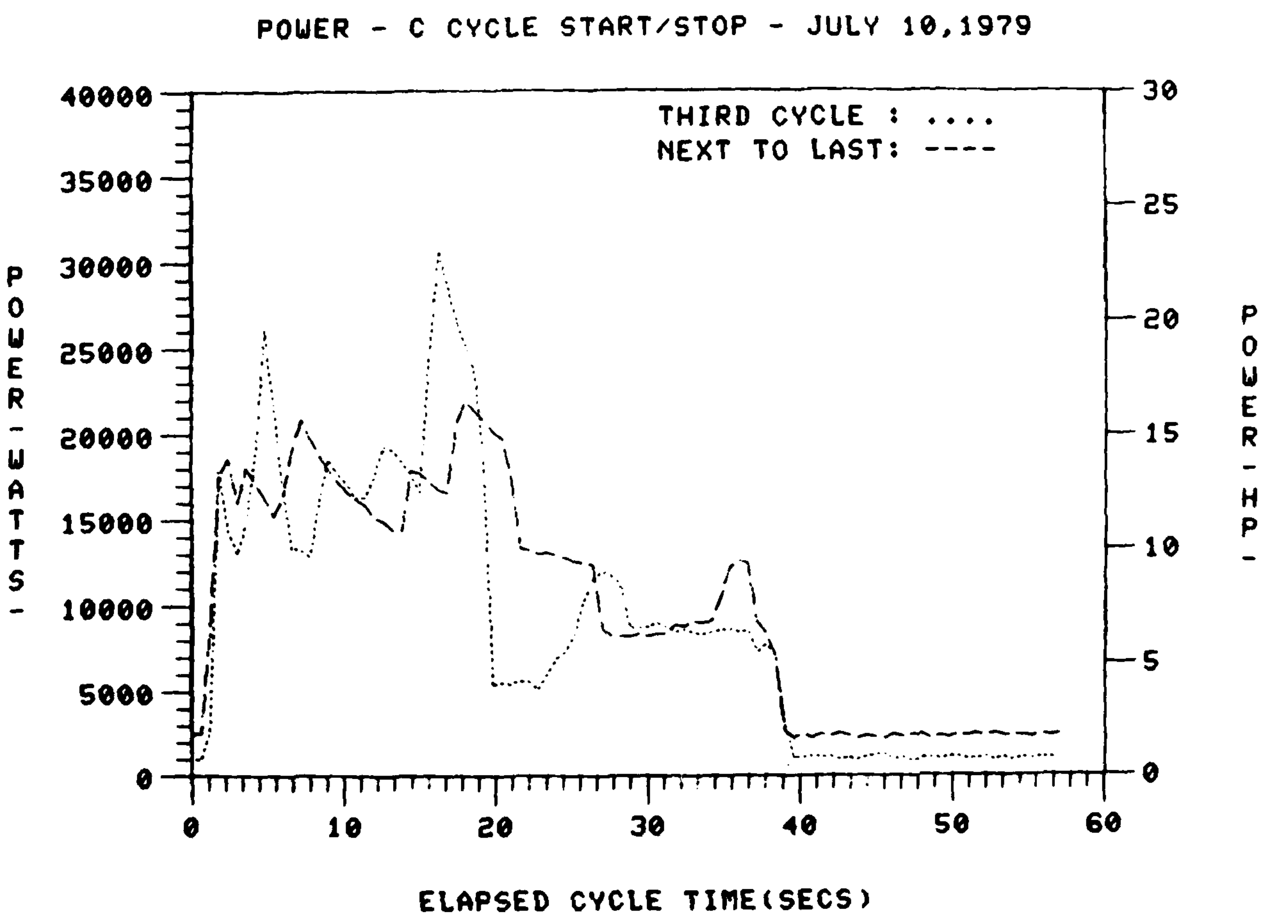

Figure 14. "C" Cycle, battery power vs time.

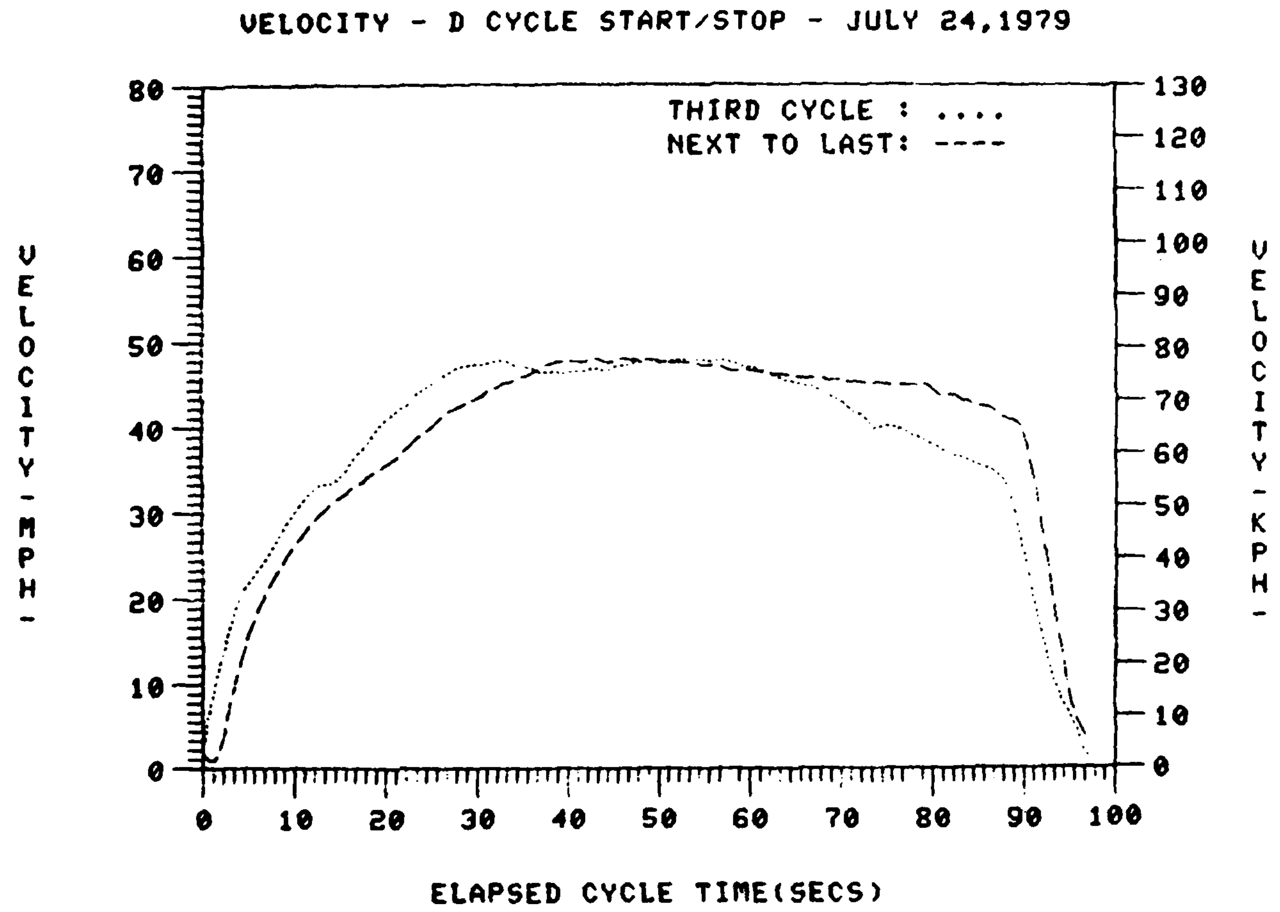

Figure 15. "D" Cycle, velocity vs time.

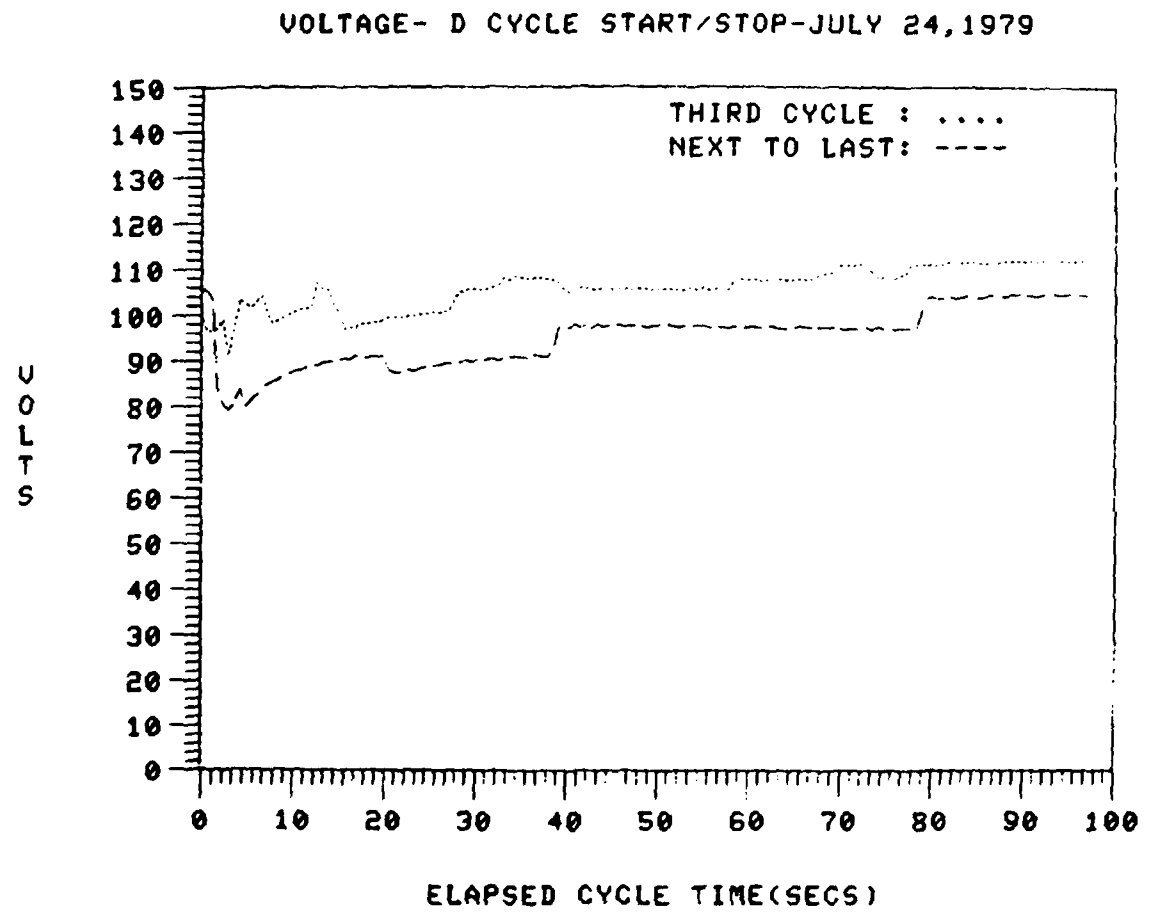

Figure 16. "D" Cycle, battery voltage vs time.

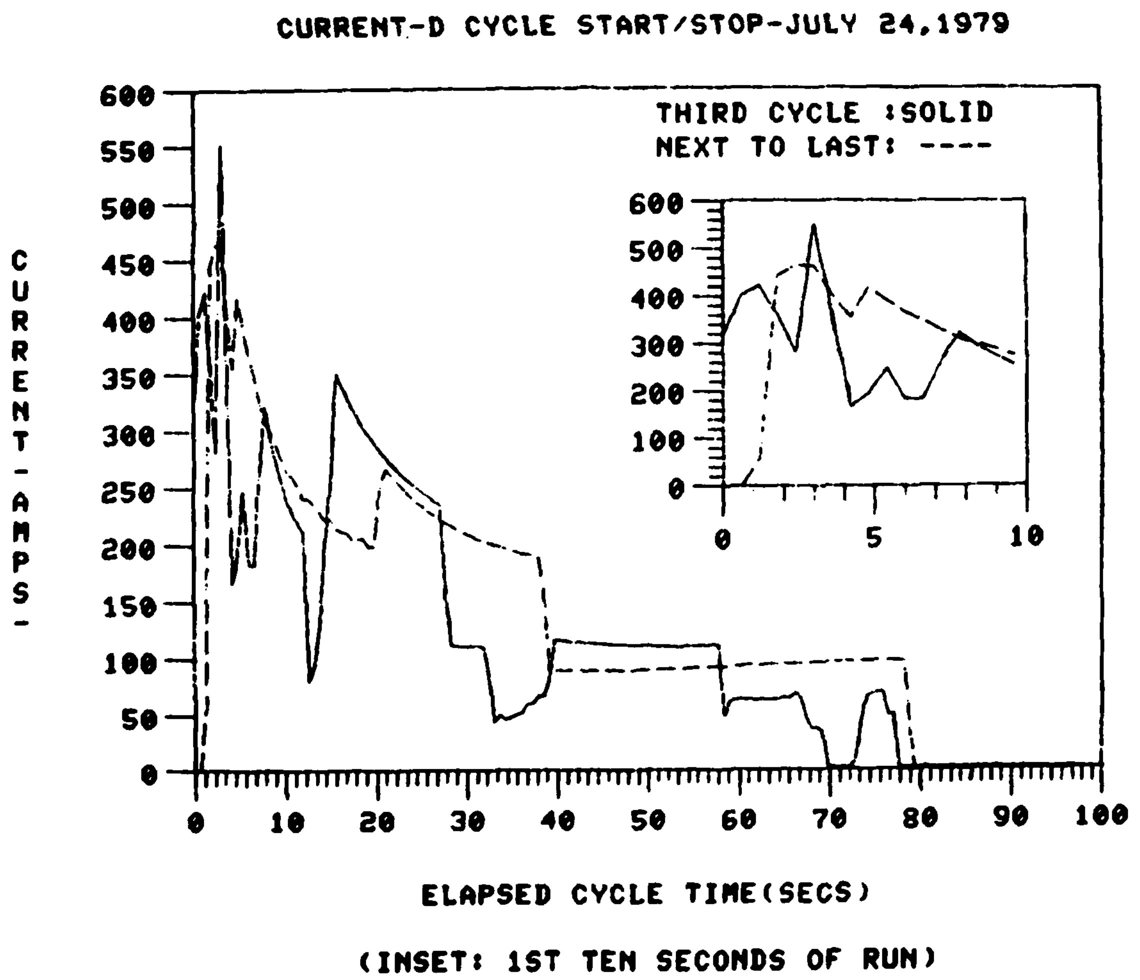

Figure 17. "D" Cycle, battery current vs time.

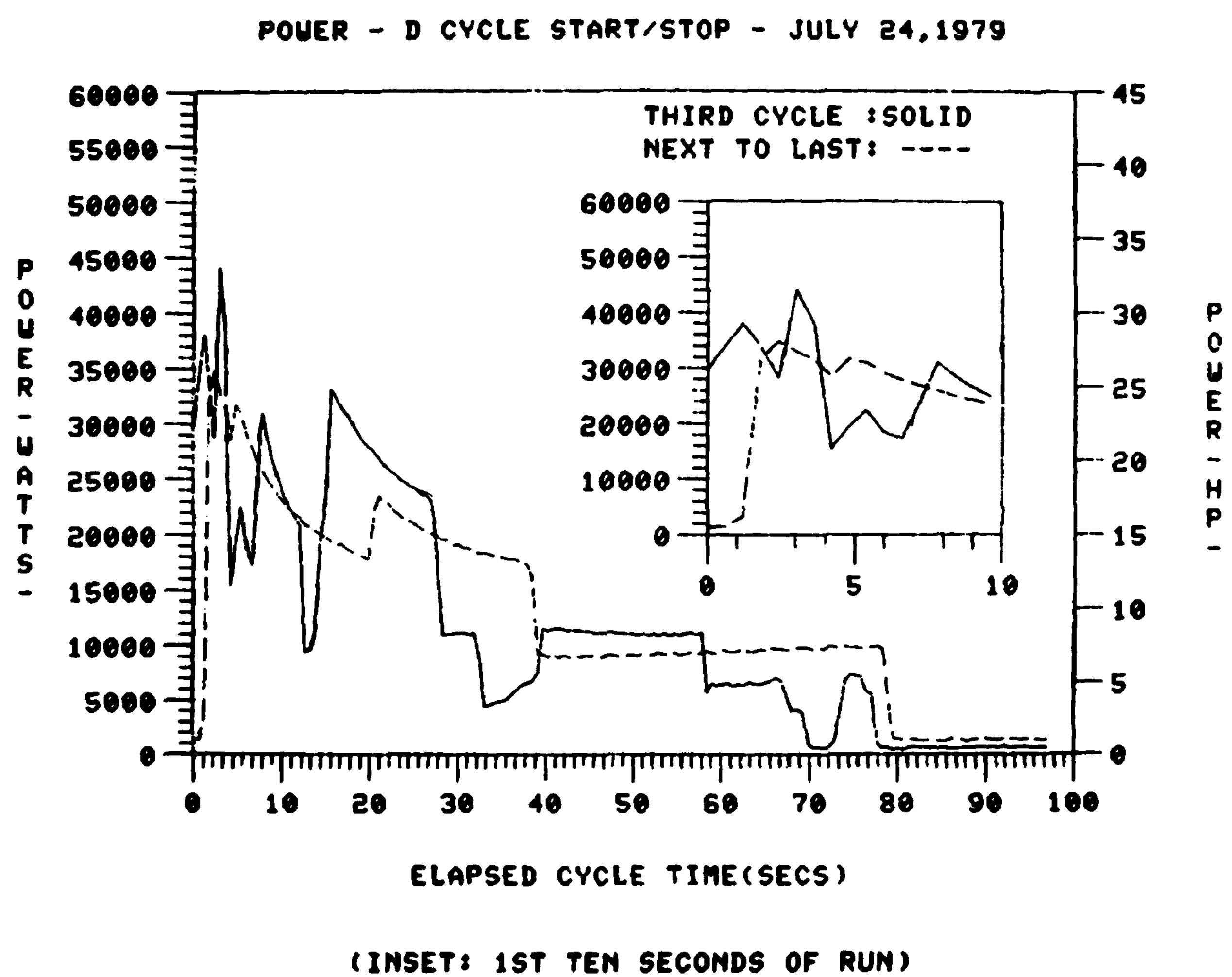

Figure 18. "D" Cycle, battery power vs time.

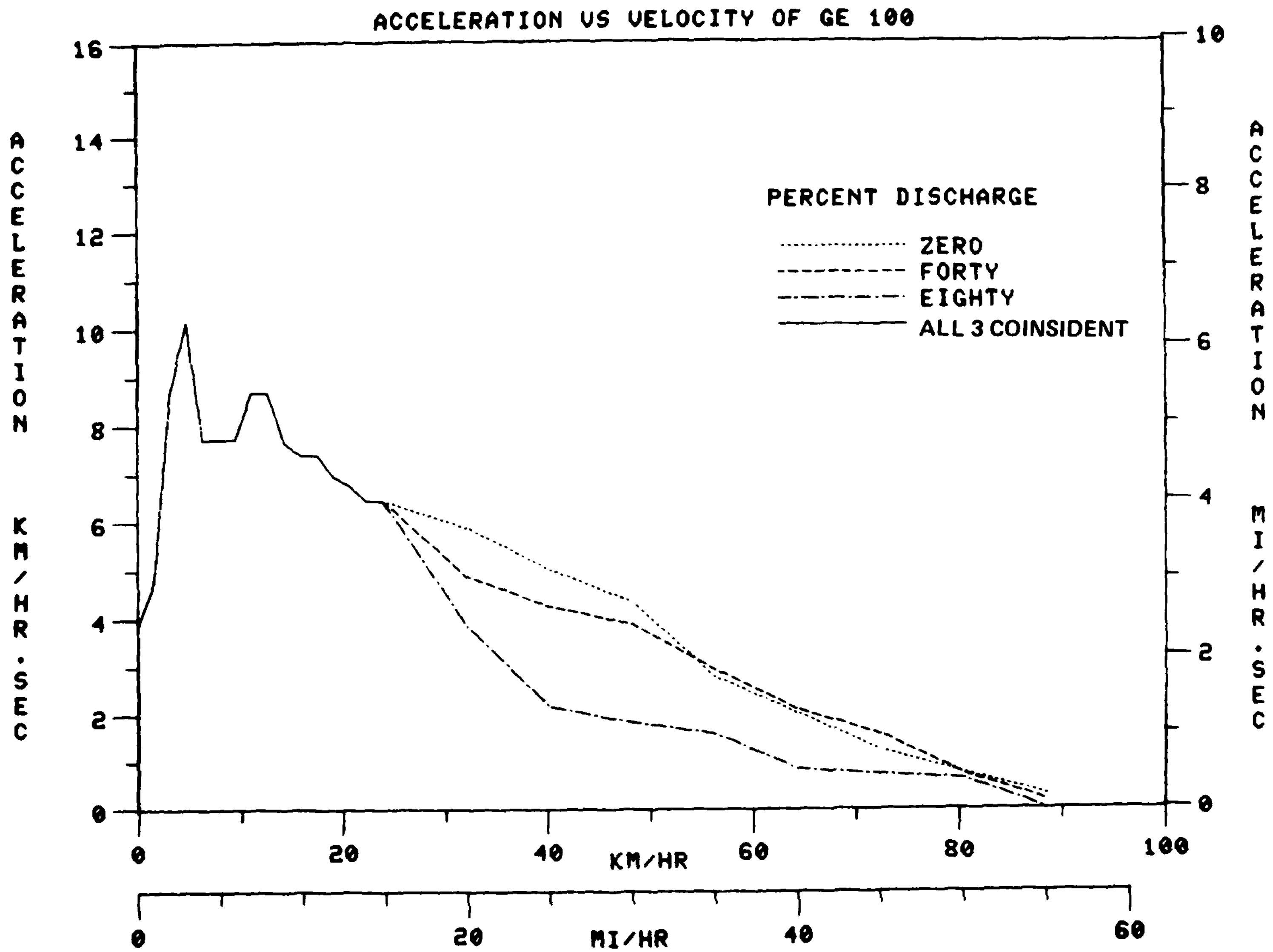

Figure 19. Acceleration vs velocity.

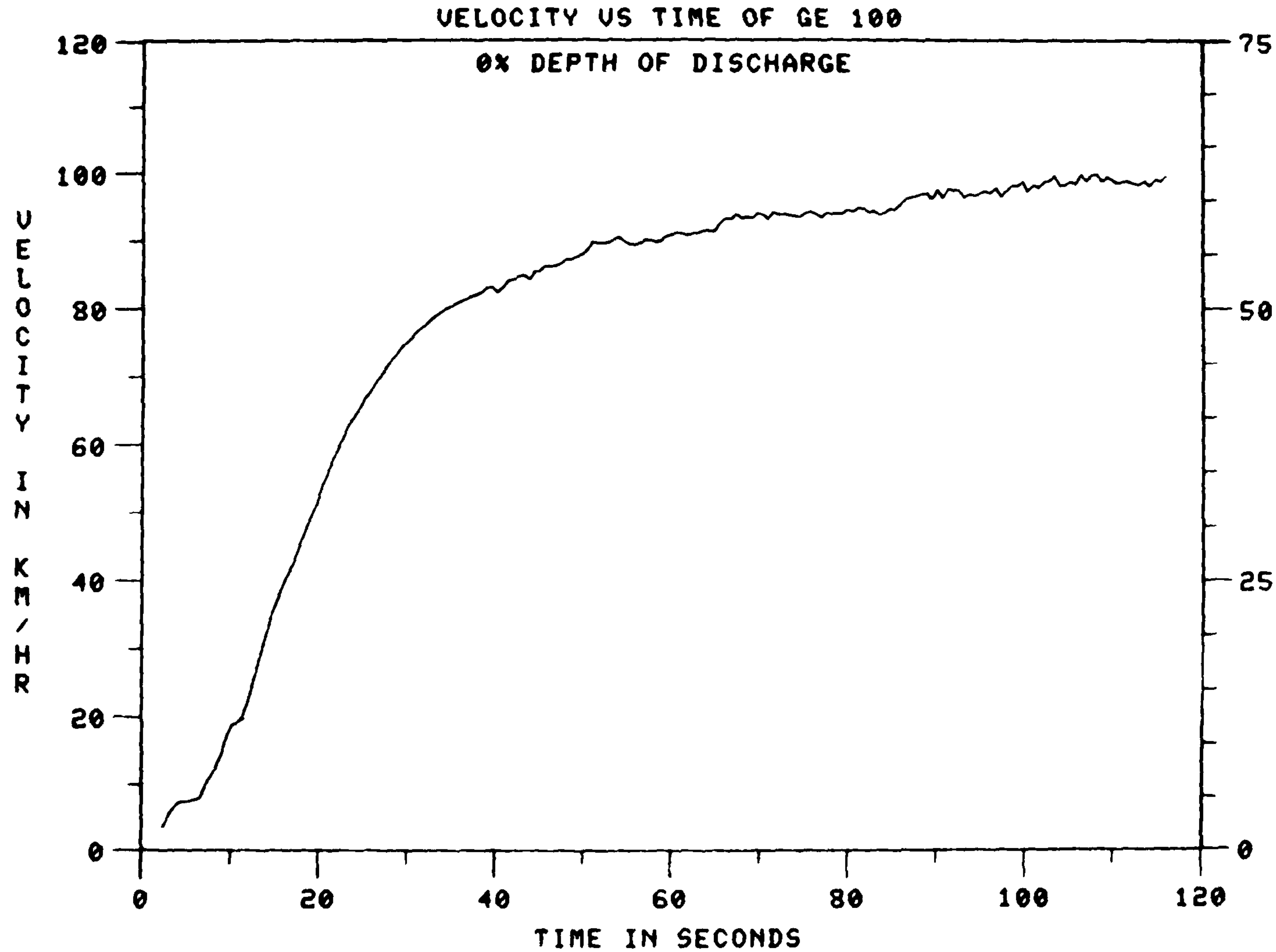

Figure 20. 0% depth of discharge, velocity vs time.

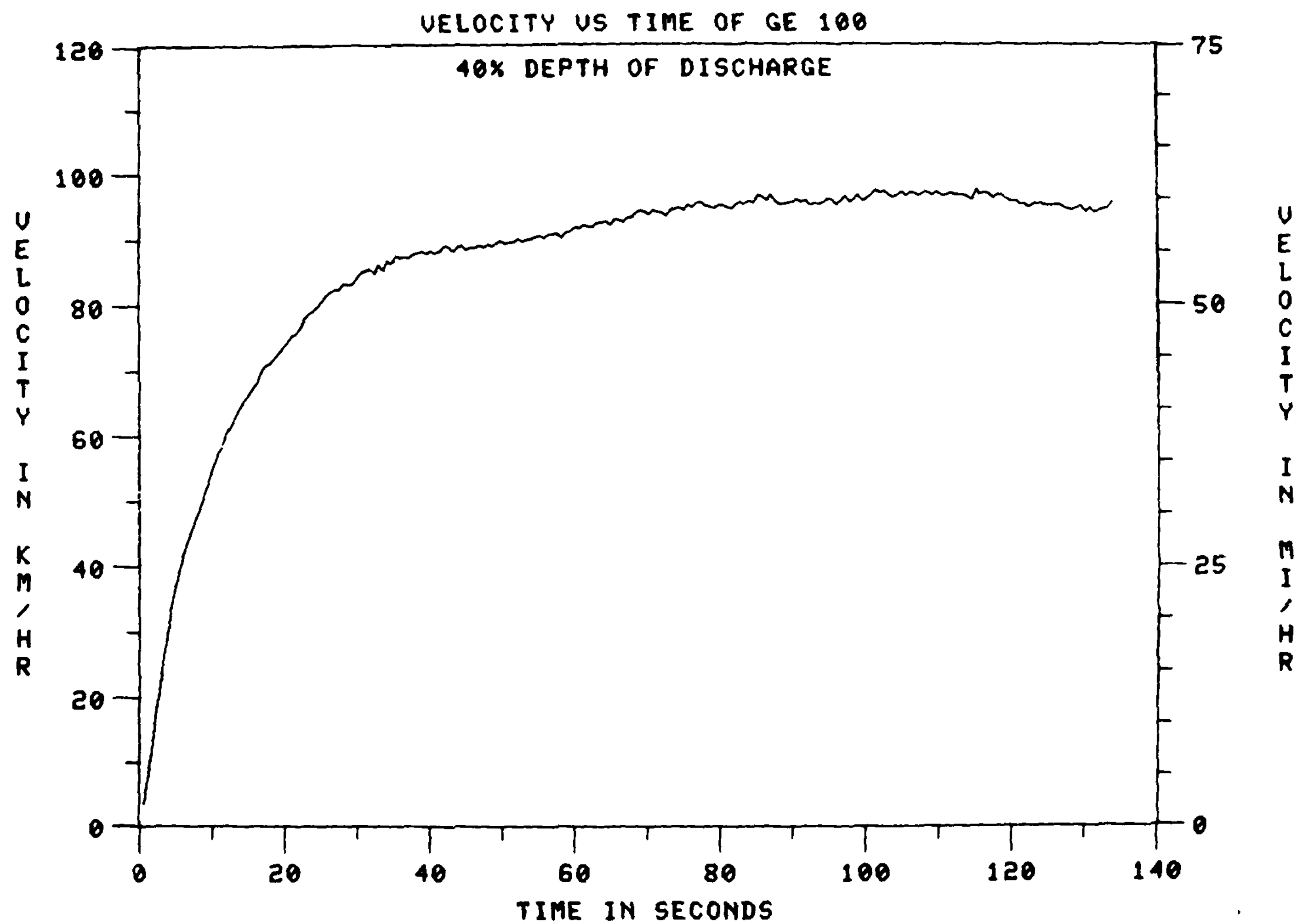

Figure 21. 40% depth of discharge, velocity vs time.

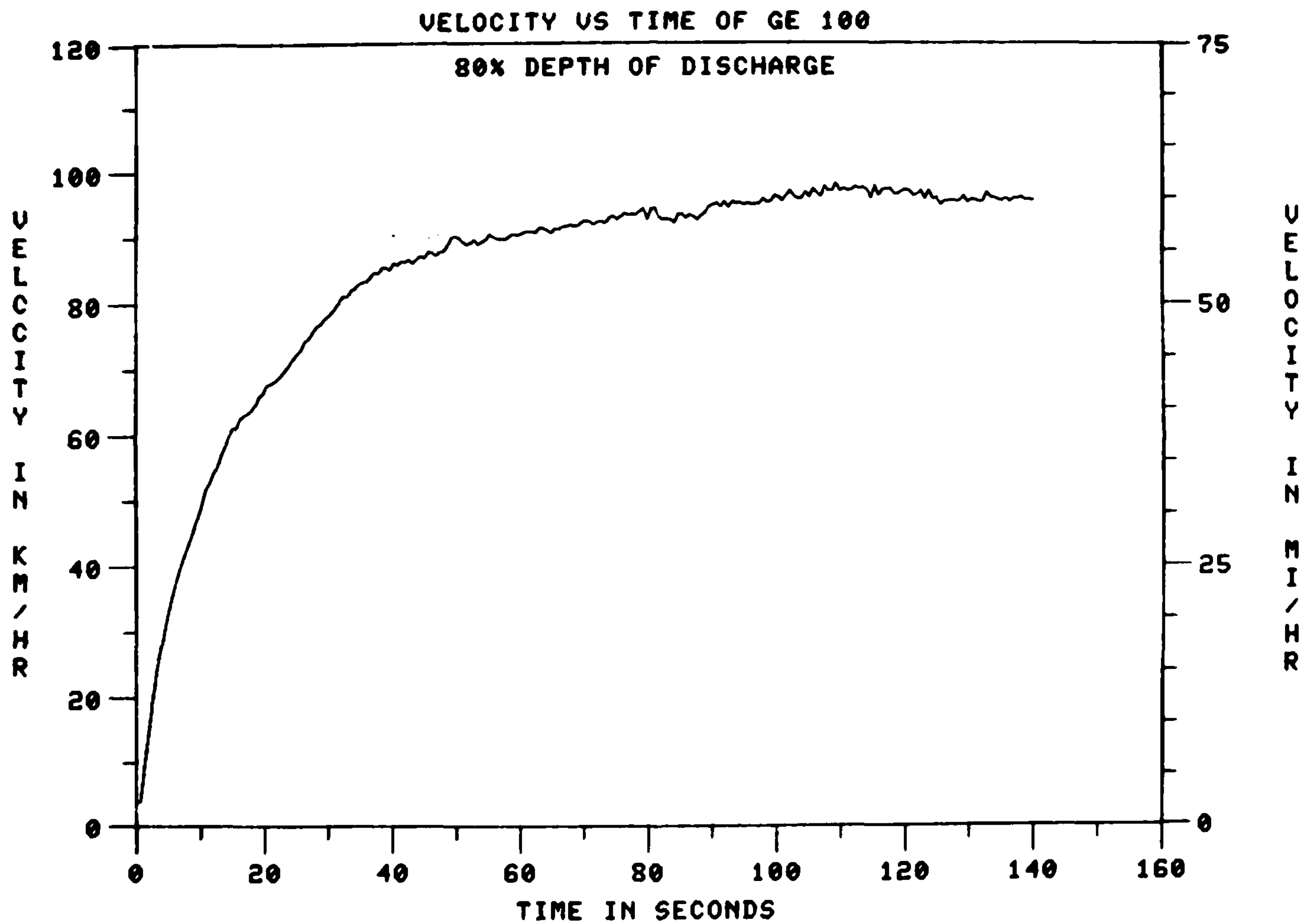

Figure 22. 80% depth of discharge, velocity vs time.

The controller limited the acceleration at low speeds to minimize jerk; therefore, gradeability at low speeds was calculated from draw-bar forces. The gradeability versus velocity results are graphed in Figures 23, 24, and 25; the tabulated results are shown in Appendix B.

5. Gradeability Limit. Gradeability limit is defined by the SAE J227a procedure as the maximum grade on which the vehicle can just move forward. The limit is determined by measuring the tractive force with a load cell while towing a dynamometer at about 1.6 km/h (1 mi/h). It is calculated from:

$$\text{Gradeability limit in percent} = 100 \tan\left(\sin^{-1}\frac{P}{W}\right)$$

where:

P = tractive force (lb).
W = gross vehicle weight (lb).

The tractive forces that the GE-100 Centennial was capable of exerting for three states of battery discharge were:

0% Discharged — 3115 N (700 lbf).
40% Discharged — 4448 N (1000 lbf).
80% Discharged — 4717 N (1060 lbf).

At a vehicle test weight of 1778 kg (3920 lb), the resulting gradeability limits were:

0% Discharged and cold — 18.1 %
40% Discharged — 26.4 %
80% Discharged and hot — 28.1 %

The values at the 40-percent and 80-percent discharged state were greater than at the 0-percent discharged state for the tractive force measurements. The cause was a combination of controller action and an increase in battery temperature. Lower tire and bearing friction with a warmed-up vehicle also decreased the propulsion forces required.

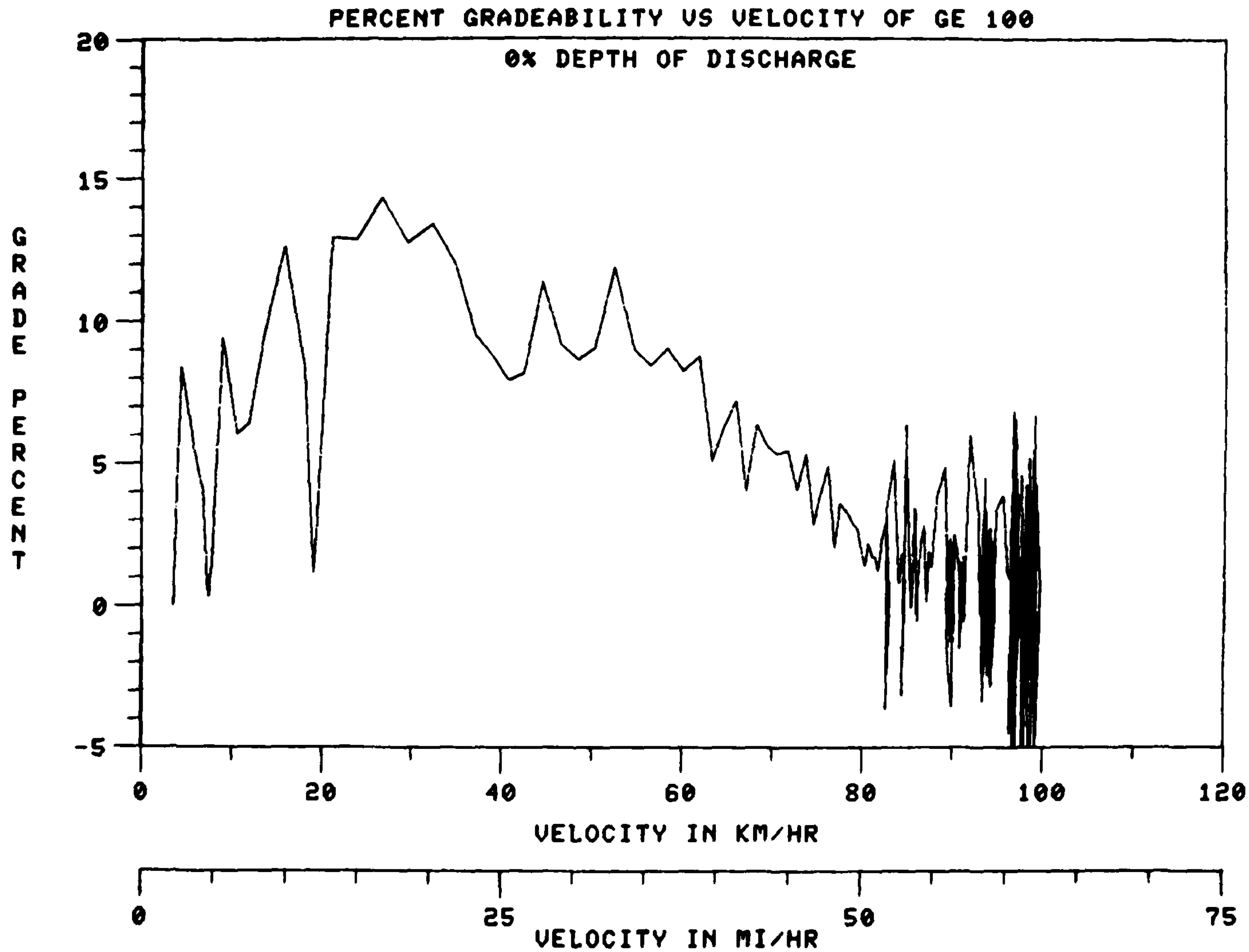

Figure 23. 0% depth of discharge, percent gradeability vs velocity.

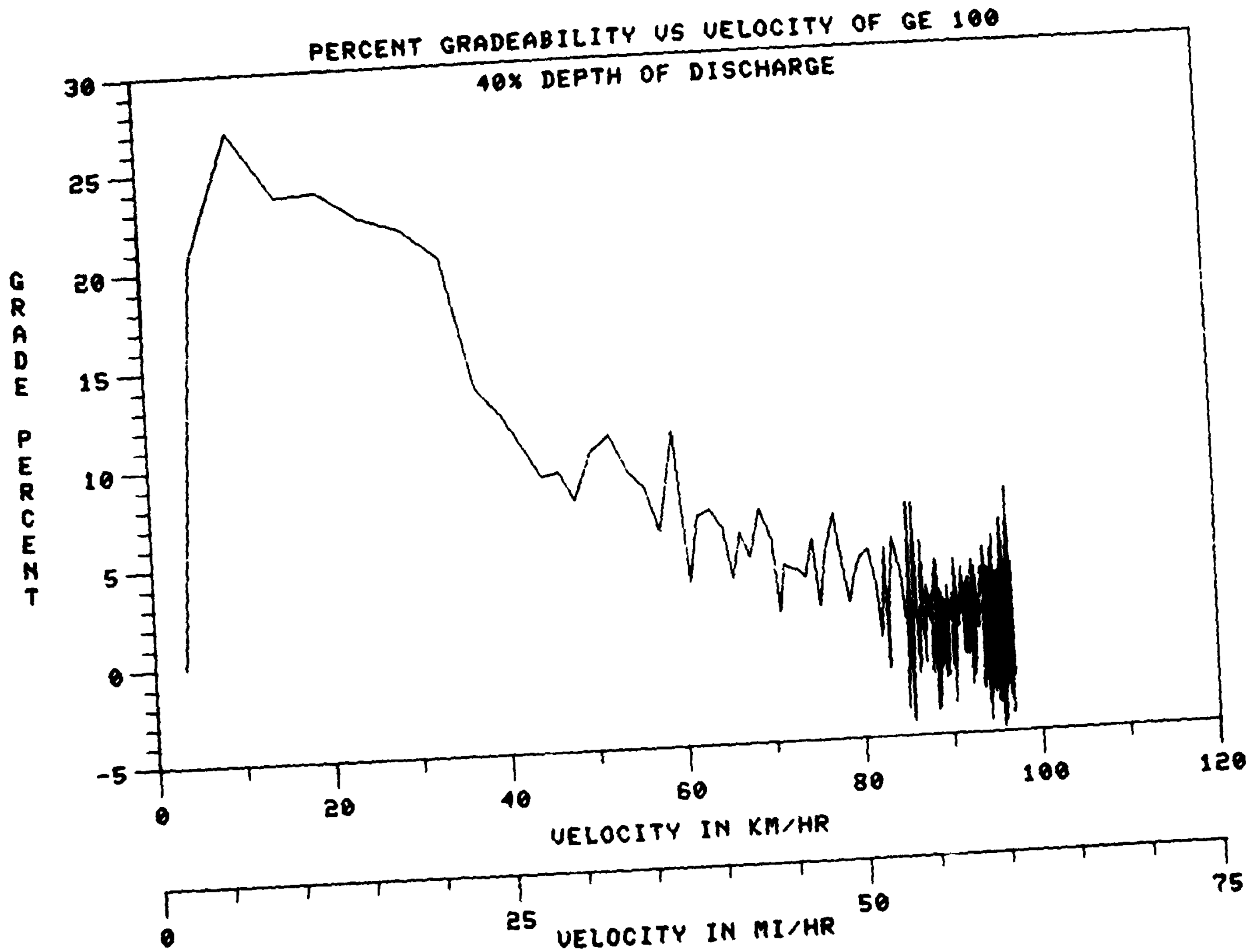

Figure 24. 40% depth of discharge, percent gradeability vs velocity.

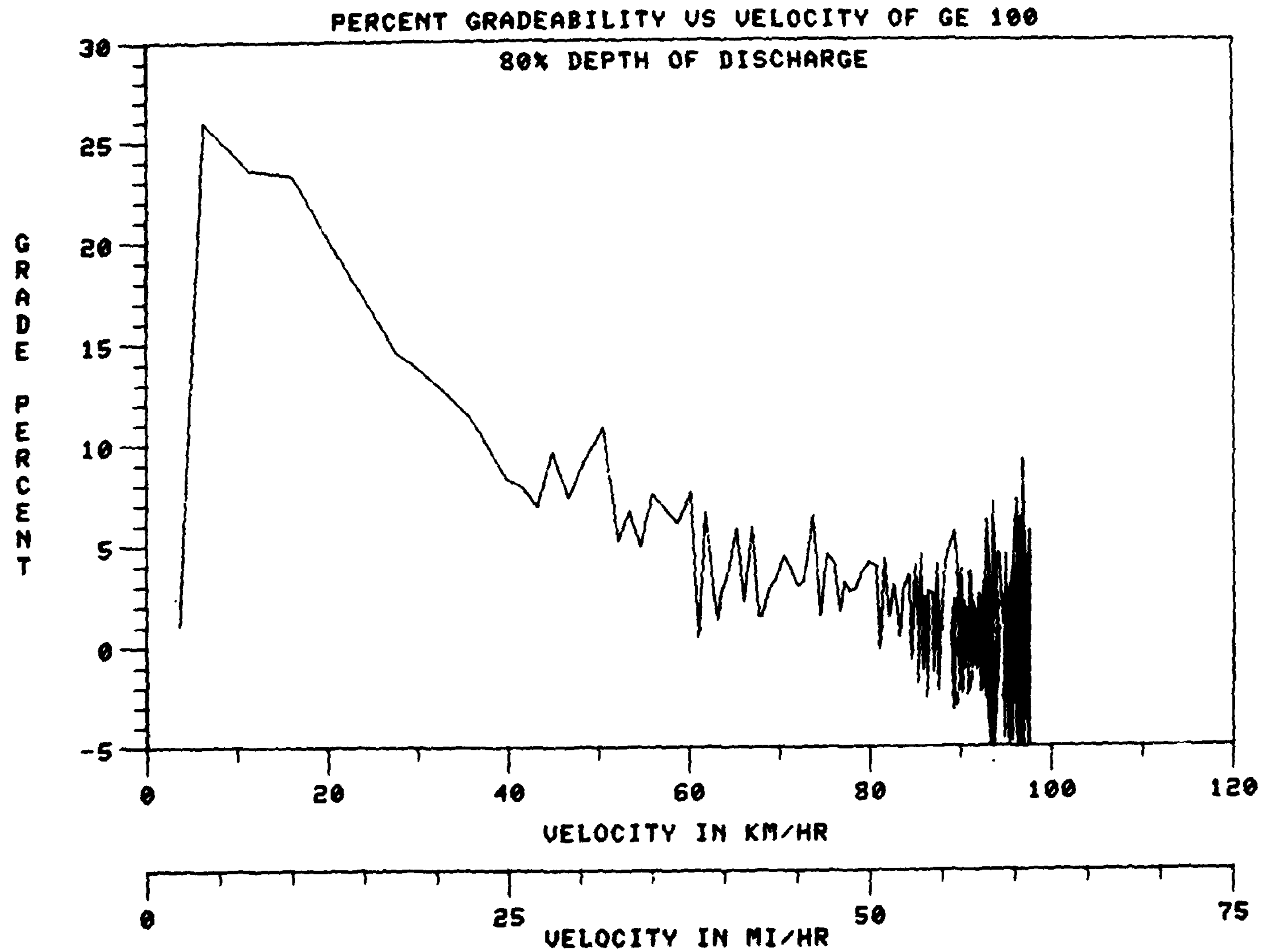

Figure 25. 80% depth of discharge, percent gradeability vs velocity.

The depth of discharge was determined by measuring the energy drawn from the battery using a Hall-effect meter. The battery was discharged by accelerating the vehicle for coast-down tests. This procedure raised the electrolyte temperature from 27°C to 52°C (80°F to 125°F) or, in effect, increased the battery capacity by 31 percent (0.7 percent capacity increase per degree Fahrenheit change). Acceleration runs also changed the drive train friction. This testing was not intended to investigate drive train friction or temperature effects on battery capacity, hence the greatest value of draw-bar force was used to calculate greadeability limit.

6. **Road Energy Consumption.** Road energy is a measure of the energy consumed in overcoming the vehicle's aerodynamic and rolling resistance.

The road energy for the vehicle at various speeds and the losses in the drive train were determined from coast-down tests (Figures 26, 27, and 28). Road energy E_n is calculated from the following equation:

$$E_n = 7.72 \times 10^{-5}\ W\ \frac{V_{n-1} - V_n}{t_n - t_{n-1}}\ \frac{\text{kWh}}{\text{km}} - E_d$$

where:

V = vehicle speed, km/h
W = gross vehicle weight, kg
t = time, s
E_d = drive train energy

$$\frac{V_{n-1} - V_n}{t_n - t_{n-1}} = a, \text{ km/h.s}$$

The results of the road energy determination are shown in Figure 29 and Appendix B.

7. **Road Power Requirements.** Road power is a measure of vehicle aerodynamic and rolling resistance. The road power, P_n, required to propel a vehicle at speed n is determined from coast-down tests. The following equation was used:

$$P_n = 6.08 \times 10^{-5}\ W\ \frac{V_{n-1}^2 - V_n^2}{t_n - t_{n-1}}$$

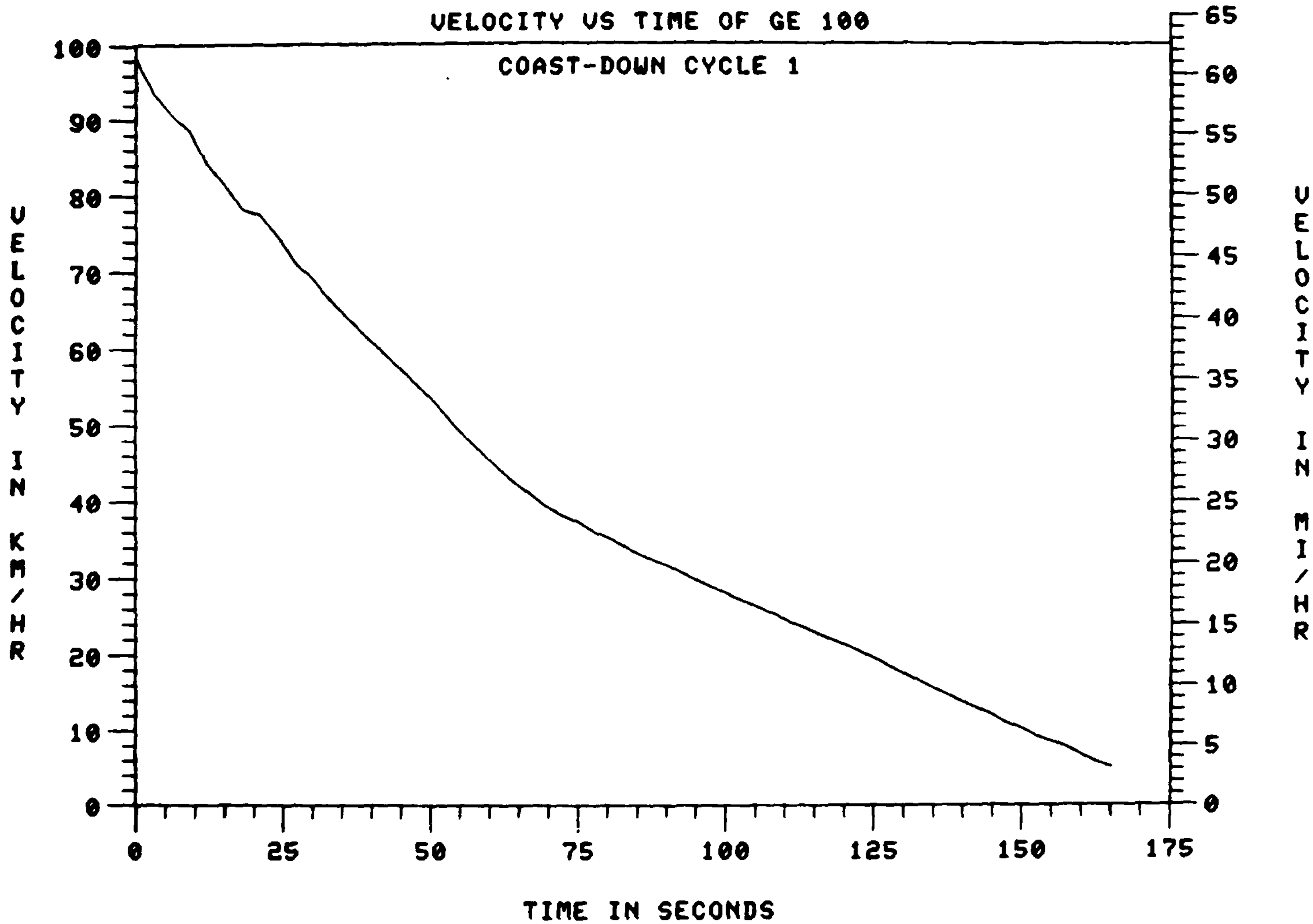

Figure 26. Coast-down cycle 1, velocity vs time.

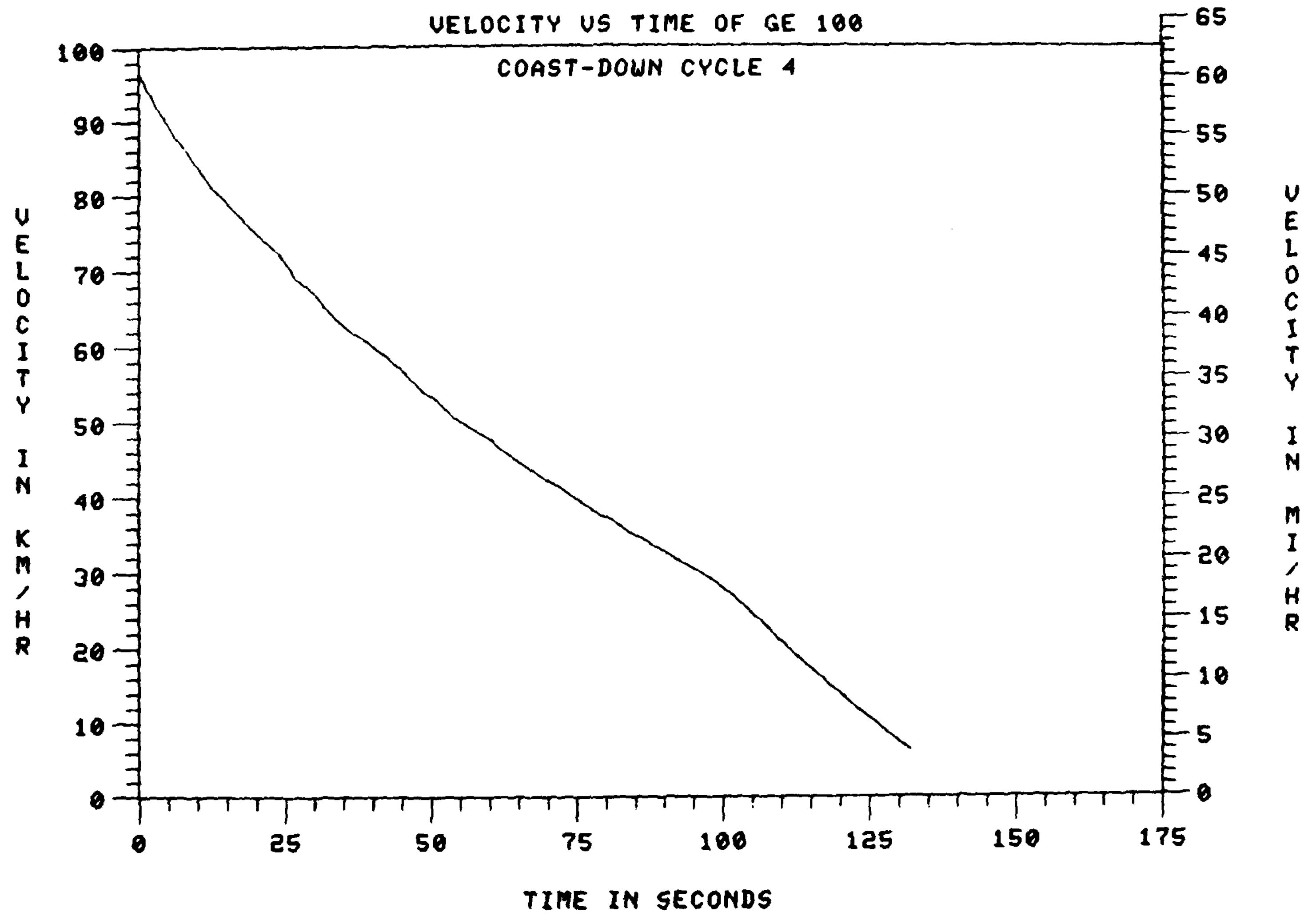

Figure 27. Coast-down cycle 4, velocity vs time.

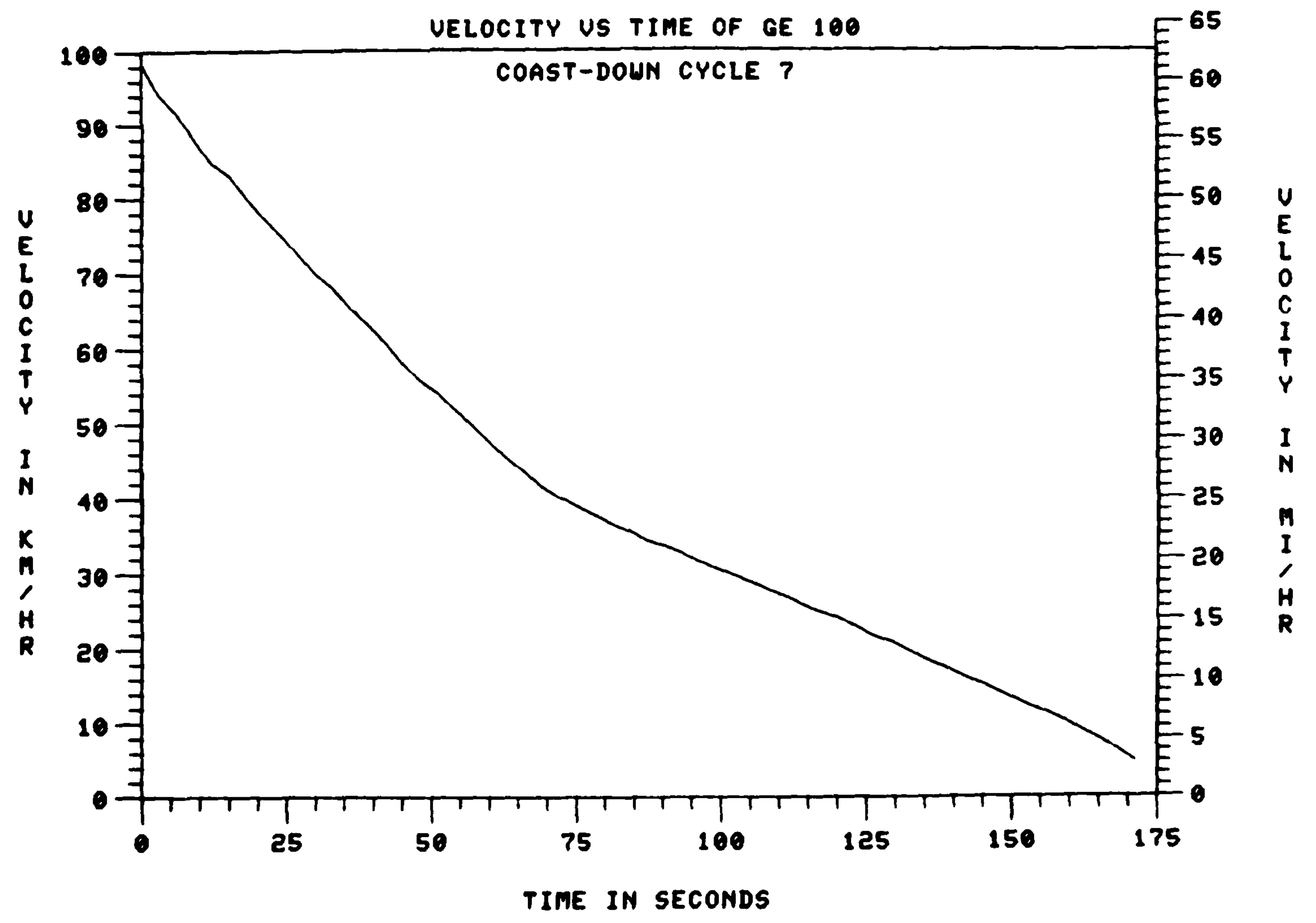

Figure 28. Coast-down cycle 7, velocity vs time.

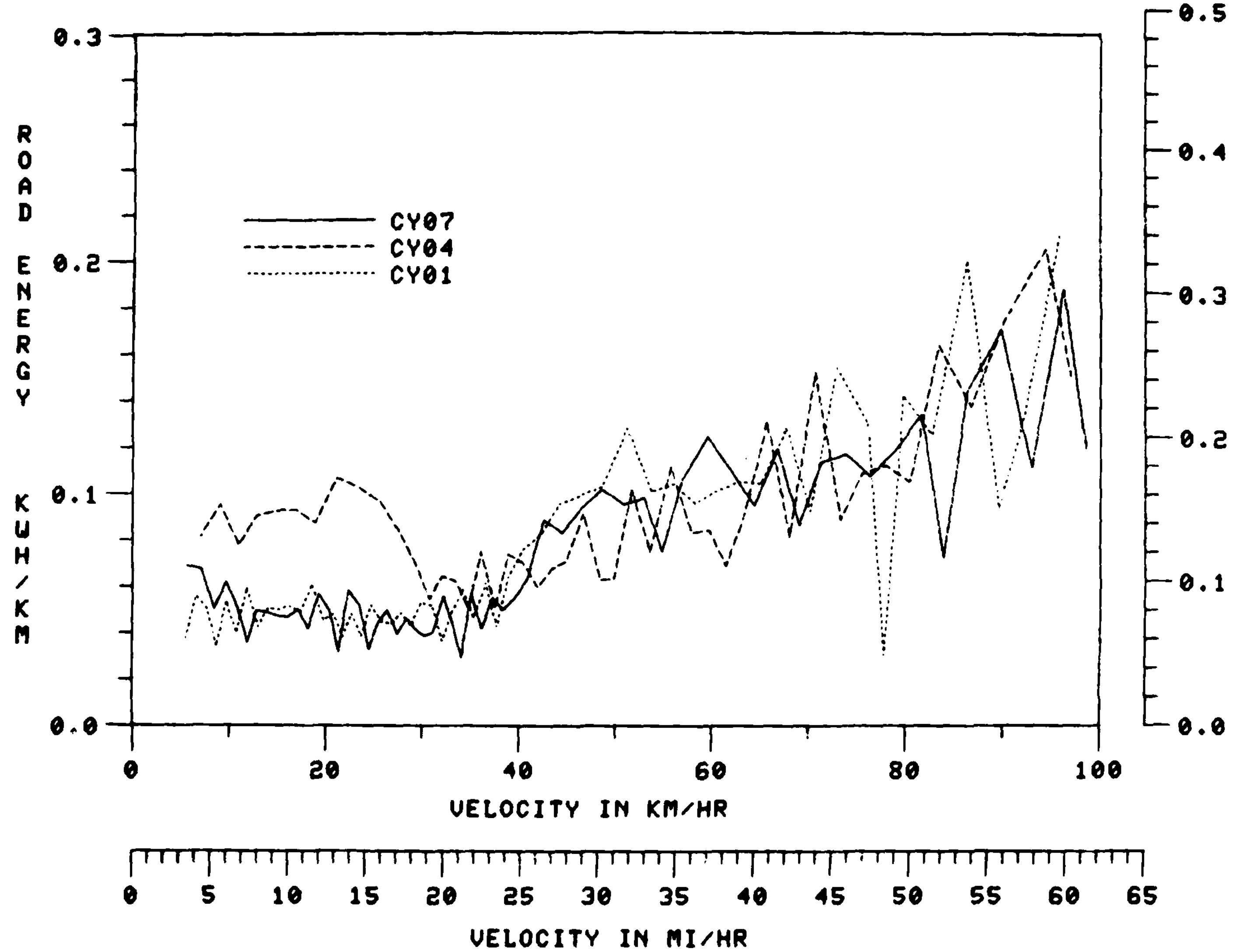

Figure 29. Road energy vs velocity.

Because there is no way to disengage the motor, these calculations include motor windage losses. The results of road power calculations are shown in Figure 30 and Appendix B. Appendix C shows a calculation approach to take windage losses into account.

8. Indicated Energy Economy. SAE J227a defines energy economy as "the vehicle range in various operating modes divided into the AC energy required to return the battery to its original state of charge. The test procedure monitored electrical power transfer at three points. A rotating watt-hour meter measured the 60-Hz a.c. input to the charger. A Hall-effect device measured the d.c. energy into the battery. A Hall-effect device also measured the d.c. energy out of the battery. The efficiency of the charger, the battery, and the overall system were then calculated as the ratio of energy out to energy in.

The Vehicle Energy Economy column of Table 1 is the system economy, which is the a.c. energy into the charger divided by the distance covered at the test speed or over the driving pattern. The Battery Energy Economy column is the d.c. energy out of the battery divided by the distance covered during the test.

Charger efficiency is the ratio of output d.c. energy to input a.c. energy expressed as a percentage. The Hall-effect devices responded from d.c. to frequencies beyond 5 kHz.

VIII. COMPONENT PERFORMANCE AND EFFICIENCY

1. Battery Charger. The GE CRD Ferro-Resonant laboratory model battery charger and the on-board accessory battery charger are described in Appendix A. The Ferro-Resonant unit charges the main propulsion batteries during a non-operating period. The auxiliary battery was charged from the propulsion batteries during operation of the vehicle. Charger efficiency was calculated to be as high as 84.3 percent. During portions of the test the auxiliary battery was charged with a separate charger at the same time the propulsion batteries were being charged.

2. Battery Characteristics. The GE-100 Centennial used the Globe-Union GC-419 lead-acid batteries for propulsion. Eighteen modules of 6 volts each were connected in series to provide a nominal operating level of 108 volts. The propulsion batteries are rated at 132.5 Ah on a discharge current of 75 A for 106 min. Figures 31 and 32 display the battery characteristics for the first 25 percent and the last 25 percent of operating range, respectively. The reduced power at speed for the last 25 percent of range reflects the reduced chassis forces due to warmed-up tires, etc. The roll-off of voltage with increasing range is a characteristic of the battery, but control of current and power is due to the motor controller.

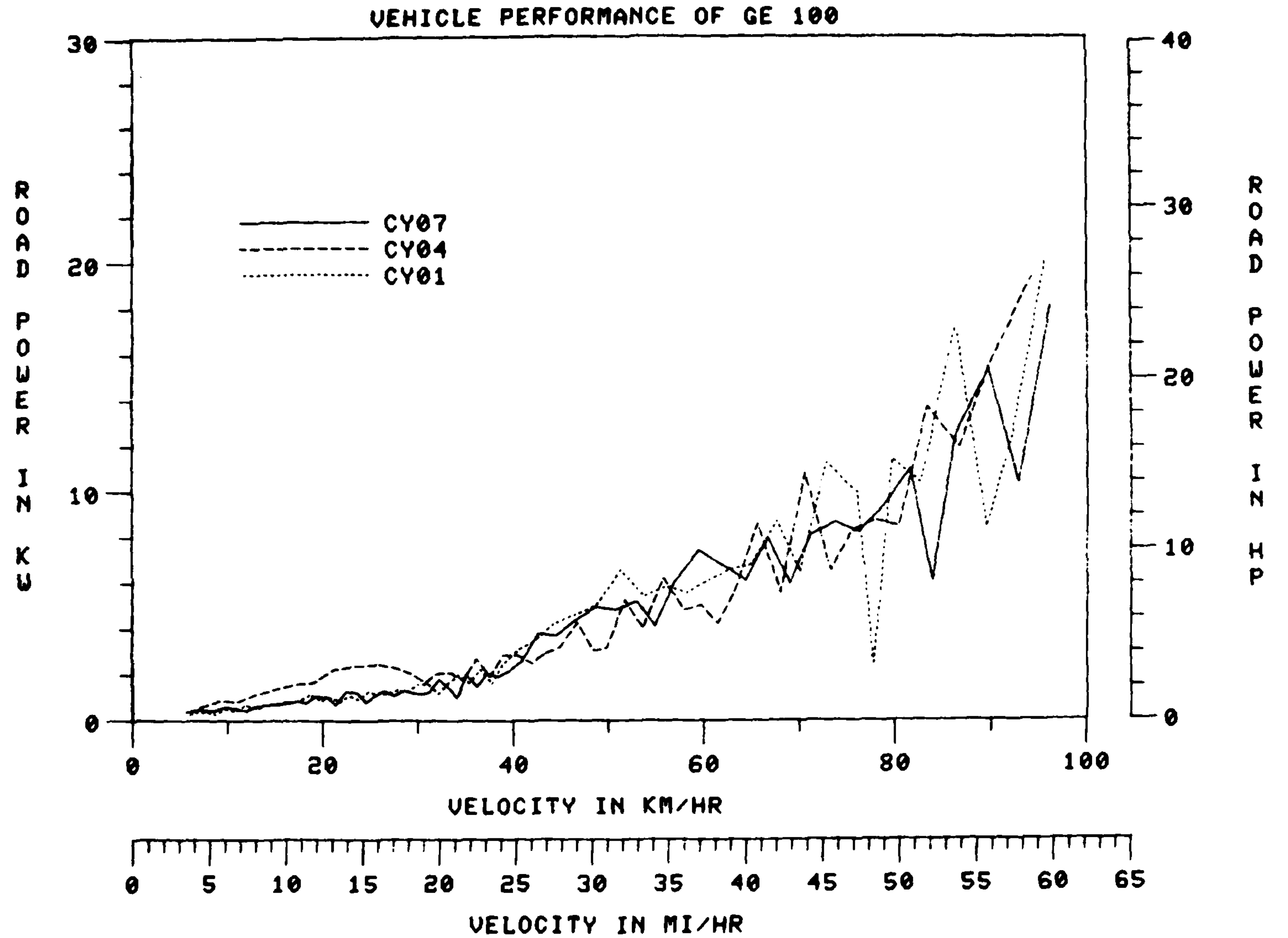

Figure 30. Road power vs velocity.

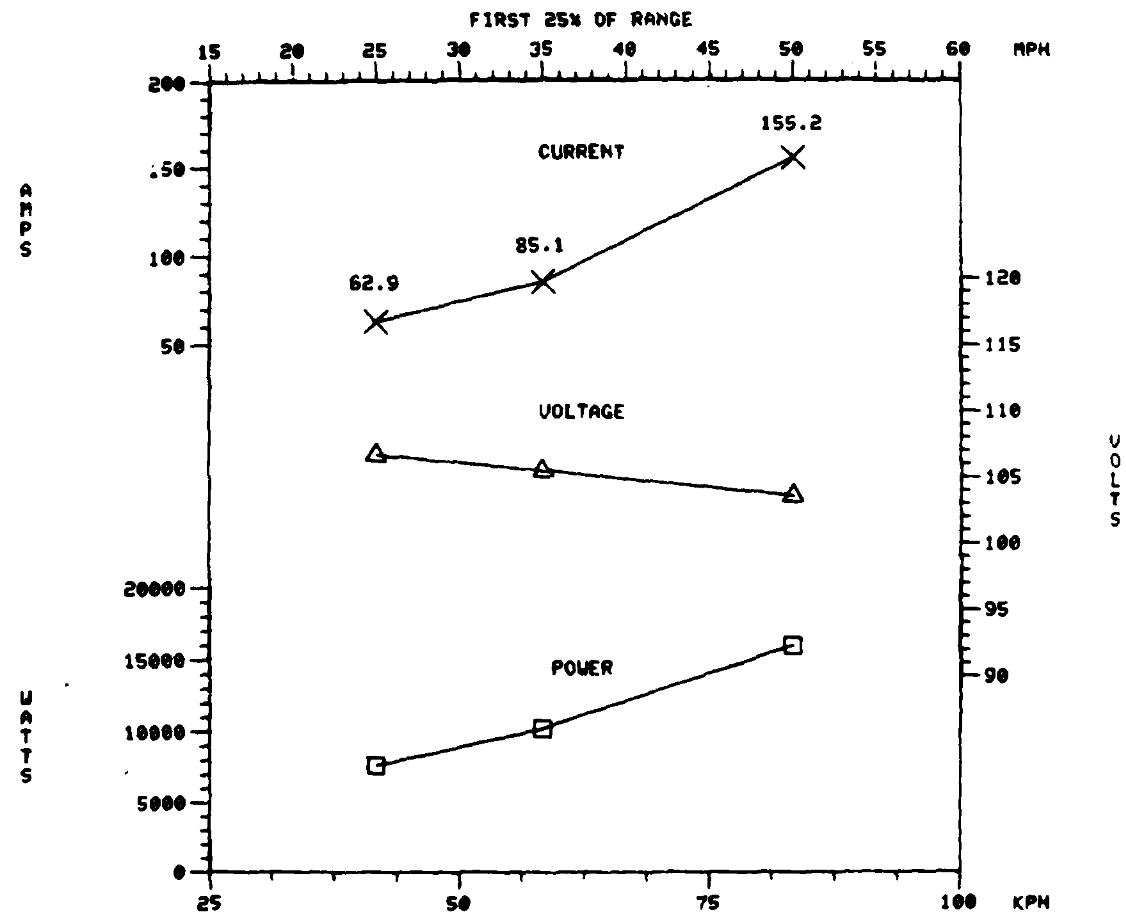

Figure 31. Constant-speed battery performance, first 25% of range.

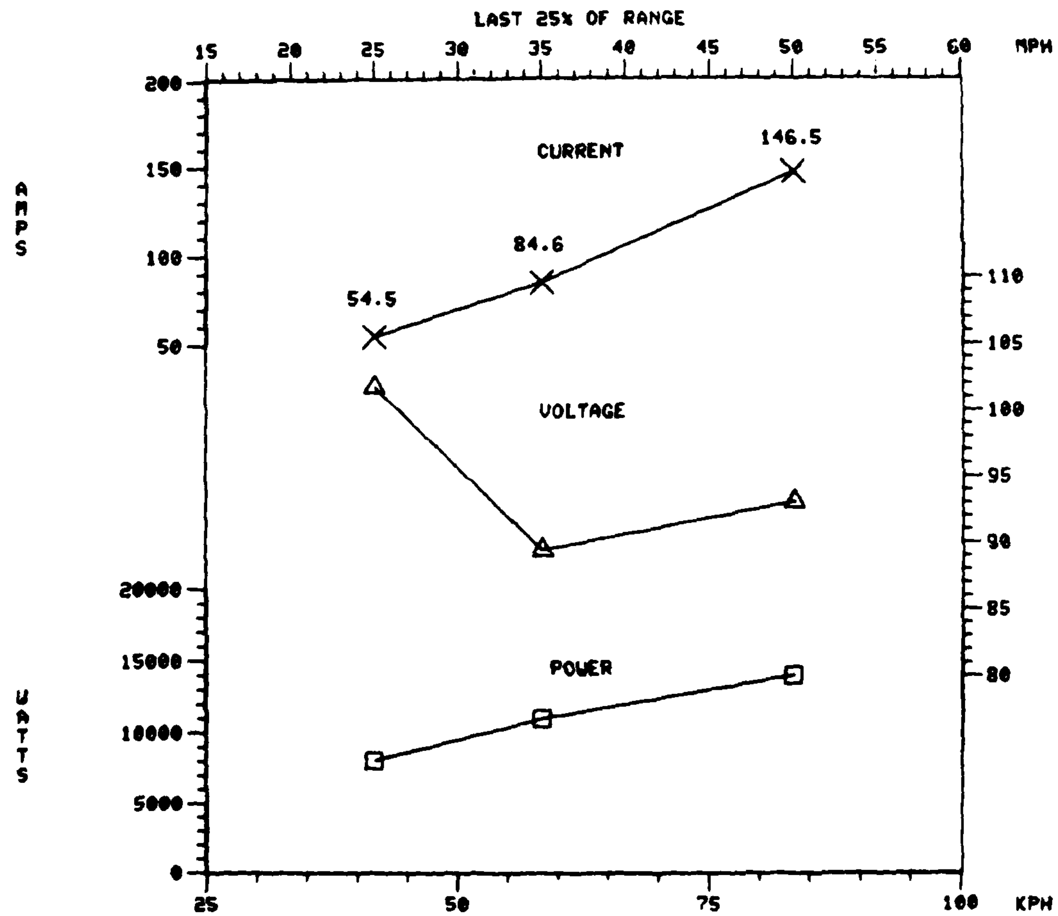

Figure 32. Constant-speed battery performance, last 25 percent of range.

3. Controller. The General Electric EV-1 Silicon Control Rectifier (SCR), model C, with current limiting and demand pickup of a contractor to bypass the controller was used. The controller has two adjustable features — creep speed and controlled acceleration — and one fixed feature — top speed. The SCR is switched on and off by an oscillator card at a rate of 50 Hz to 300 Hz with duty cycle varying from 5 percent at 50 Hz to 50 percent at 300 Hz. When the oscillator reaches approximately 95 percent at 50 Hz, the bypass relay is energized to provide uninterrupted battery voltage directly to the motor. The oscillator is controlled by the position of the accelerator pedal.

Wave form analysis of the controller for harmonic content was calculated by Fourier Transformation. The analysis indicates that 98 percent of the energy is transferred at frequencies below 5 kHz in all modes.

4. Motor. The d.c. series 5BT2364 CII (S/N JL42-99) motor is described in Appendix A. The significant design feature of this vehicle is that the motor is connected directly to the drive train, without clutch or transmission. This feature not only allows lower weight, but optimizes the electro-mechanical characteristics of a d.c. series motor for starting torque, speed regulation, and reversing. The vehicle did not have regeneration or plugging in the tested configuration. Having the motor connected directly to the drive train required a correction to the coast-down tests to develop the aerodynamic drag plus rolling resistance. See Appendix C for procedure.

5. Drive Train. The vehicle employed a chain drive with a 1.36:1 ratio and a differential with 4.135:1 ratio for an overall drive line ratio of 5.62:1. Motor/vehicle speed ratio is 80.5 r/min/mi/h. Tires, brakes, etc., are described in Appendix A. Manufacturer's figure of 98-percent drive train mechanical efficiency was provided.

IX. RELIABILITY

The vehicle was not available long enough to conduct an evaluation of reliability. However, there was an interruption in the testing to allow the car to be demonstrated to the public. When the car was returned, it required 2.5 gal of water to service the battery and one module had to be replaced because of a burned post. These problems are associated with training the operators concerning routine maintenance.

The on-board auxiliary charger was bypassed in favor of charging from a MERADCOM charger because of excessive draw from the on-board charger.

APPENDIX A

VEHICLE SUMMARY DATA SHEET

1. Vehicle Manufacturer:

General Electric Co.
Corporate Research and Development
1 River Road Bldg K-1
Schenectady, NY 12345

Triad Associates
32049 Howard
Madison Heights, MI 48071

2. Vehicle Description:

Name: Centennial Electric
Model: GE-100
Availability: One-of-a-kind experimental prototype
Price: Estimated replacement value $250K

3. Vehicle Weight:

Curb weight: 1551 kg (3420 lb)
Driver weight: 68 kg (150 lb)
Passenger weight (3): 159 kg (350 lb)
Gross weight: 1778 kg (3920 lb)

4. Vehicle Size:

Wheelbase: 2.34 m (92 in.)
Length: 4.06 m (160 in.)
Width: 1.68 m (66.1 in.)
Height: 1.36 m (53.6 in.)
Headroom: 0.97 m (38.3 in.)
Leg room: 1.06 m (41.9 in.)
Frontal area: 1.77 m² (19 ft²)
Road clearance: 0.15 m (6 in.)
Number of seats: 4
Wheel track: 1.38 m (54.5 in.) front; 1.47 m (58.0 in.) rear

5. Auxiliaries and Options:

Lights: Headlights (4), front parking and direction, front side markers (parking and direction), rear lamp assembly (backup, taillight, directional, stop), rear license plate lamp, rear side markers, dome light, 2 courtesy lamps, dash cluster illumination lamps.

Windshield wipers: Yes
Radio: Yes CB transceiver, Am/Fm stereo
Ampmeter: Yes
Speedometer: Yes
Left-hand drive: Yes
Regenerative braking: No
Power steering: No
Windshield washers: Yes
Heater: Yes (gas)
Fuel gage: Yes (state of charge)
Tachometer: No
Odometer: Yes
Direct-drive transmission
Mirrors: Yes (3)
Power brakes: No

6. Propulsion Batteries:

Types: Lead-acid (motive GC-419)
Modules: 18 (6 volts)
Battery voltage: 108 volts
Size: 0.26L x 0.18W x 0.29H; 0.014 m^3 each 0.252 m^3 total (10.2L x 7.1W x 11.4 H: 826 in^3 each, 14859 in^3, 8.6 ft^3 total)
Manufacturer: Globe Union
Cells: 3 per module 54 total
Capacity: 132.5 Ah (75 A for 106 min)
Weight: 30.9 kg each, 556.2 kg total (68.1 lb ea, 1226 lb total)

7. Auxiliary Battery:

Type: Lead-acid (SCI)
Manufacturer: Globe Union
Cells: 6
Voltage: 12 volts
Capacity: 30 Ah @ 20-h rate
Size: 0.197L x 0.130W x 0.187H m, (7.75L x 5.13W x 7.38H in.)
Weight: 10 kg (21.8 lb)

8. Controller:

Type: SCR EV-1C
Manufacturer: General Electric
Voltage rating: 84 to 144 volts
Current rating: 850A peak 375 max avg batt.
Size: 0.356L x 0.205W x 0.177H m (14L x 8W x 7H in.)
Weight: 23.1 kg (51 lb)

9. Propulsion Motor:

Type: d.c. series 5BT 2364 CH S/N JL 42-99 blower vent
Manufacturer: General Electric
Voltage: 109 V at rated power
Power: 16.26 kW (21.8 hp)
Insulation class: F
Current: 170A at rated power
Size: 0.29 m dia. (11.38 in.), 0.51 mL (20.0 in.)
Weight: 104.4 kg (230 lb)
Rated speed: 3270 r/min
Maximum speed: 6800 r/min

10. Battery Charger (Propulsion):

Manufacturer: General Electric
Input voltage: 220 V single-phase
Recharge time: 6 to 8 h
Type: Laboratory Model Ferro-Resonant
Off board
Peak current demand: 27.5 A
Automatic turn off: Adj. time 12 h max
Weight: 43 kg (95 lb)

11. Battery Charger (On Board):

Type: d.c.-d.c. transformer isolated
Manufacturer: EVA
Peak current: 2.5 A
Size: 0.32L x 0.010W x 0.08H m (12.5L x 4.0W x 3.0H in.)
Weight: 2.7 kg (6 lb)
Automatic turn off: Yes, regulated
Input voltage: 85- to 125-V d.c.
Recharge time: 4 to 6 h

12. Body:

Manufacturer: GE/Triad
Type: Hatchback
Materials: Stainless steel under body; steel and fiberglass body
Doors: 3, 2 parallelogram linkage side, 1 gull-wing rear hatch
Windows: Glass windshield: Lexan® -2 fixed-in side doors, 2 sliding-in doors, 2 fixed-in rear quarters, 1 fixed-in rear door
Seats: 2 full bucket in front — 2 removable rear facing jump seats.
Cargo space volume: 1.36 m^3 (48 ft^3) to window level
Cargo space dimension: 1.83L x 1.22W x 0.61 H m (6.0L x 4.0W x 2.0H ft)

13. Chassis:

Type: Unibody
Manufacturer: Triad Services
Material: Stainless steel backbone, fiberglass panels
Modification: None — original design
Springs and shocks: Coil, Monroe take-aparts
Axles: Audi Fox Front; Subaru hubs, no axle-rear Morse Hyvo chain, Chrysler parking pawl, BW differential 1.36: 1 chain, 4.135: 1 differential, 5.620:1 driveline ratio (80.5 r/min/mi/h)
Steering: Triad Services, new design, 18.5: 1 turning ratio, 9.75 m (32 ft) turning diameter
Brakes: Front, inboard Chevelle, copper drums; rear, subaru drums
Parking: Vega coupled to front Chevelle
Regenerative: No
Tires: Michelin B78-13 radial 165 to 179 K Pa (24 to 26 lb/in.^{2})* 0.30 m (11.8 in.) rolling radius
Wheel track: 1.38 m (54.5 in.) front; 1.47 m (58.0 in.) rear

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* This pressure range is the normal manufacturer's recommended operating band; however, with permission of the tire manufacturer GE increased the pressure to 283 kPa (41 lb/in.^{2}). The pressure of 283 kPa was maintained for the tests in this report.

Motor Characteristics Data

IBATT	IARM	VM	TORQUE	RPM	HP	LOSSES WATTS	EFF.
177.	560.	27.2	166.5	0.	0	15012.	0
171.	459.	34.9	129.5	312.	7.68	10299.	35.8
221.	377.	59.5	101.8	1046.	20.27	7306.	67.4
280.	309.	96.2	78.7	2164.	32.45	5494.	81.5
245.	253	105.4	60.8	2620.	30.33	4075.	84.7
201.	208.	107.5	46.6	2916.	25.88	3023.	86.5
165.	170.	109.2	35.0	3272.	21.82	2325.	87.5
135.	140.	110.6	25.4	3750.	18.17	1899.	87.7
111.	114.	111.8	17.8	4404.	14.90	1688.	86.8
91.	94.	112.8	11.6	5372.	11.87	1732.	83.6
74.	77.	113.5	6.8	6778.	8.80	2178.	75.1

APPENDIX B. TABULATIONS OF GRAPHED DATA.

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
0.000000000	26.437885000	110.196605000	2698.087890000	1.201100000
.599999760	52.152788800	109.409334000	5823.291610000	1.604400000
1.199999880	66.816932200	108.130717000	6856.883080000	2.385400000
1.800000000	59.744953100	110.904591000	7534.504960000	3.231200000
2.399999760	52.916572700	108.858803000	6030.358890000	3.909200000
2.999999880	141.594167000	105.885041000	13228.273700000	4.768500000
3.600000000	131.842601000	105.333393000	12759.464000000	5.826500000
4.199999760	104.440268000	104.734844000	10994.157200000	6.924400000
4.799999880	100.458949000	105.296543000	10285.126300000	7.869200000
5.400000000	89.834486300	106.236801000	9590.636570000	8.653600000
5.999999760	77.372882500	105.340094000	8821.114040000	9.204700000
6.599999880	87.565972000	106.150815000	8617.536660000	9.628000000
7.200000000	82.666082600	108.168685000	9057.263810000	10.170000000
7.799999760	78.342203000	105.642718000	7678.172430000	10.651000000
8.399999880	76.111751000	106.560643000	7700.275120000	11.009000000
9.000000000	71.234698900	107.925245000	8057.989670000	11.451000000
9.599999760	73.457538500	105.636018000	7089.542950000	11.831000000
10.199999880	97.662636900	105.752155000	9365.538140000	12.148000000
10.800000000	90.471395800	106.030212000	9430.101260000	12.701000000
11.399999760	88.162281700	106.491407000	9134.041570000	13.210000000
11.999999880	91.110842800	106.710280000	9177.665300000	13.556000000
12.600000000	93.523993900	106.033562000	9293.995230000	14.045000000
13.199999760	92.613035700	106.365221000	9478.378180000	14.431000000
13.799999880	100.032651000	105.227307000	10037.343500000	14.850000000
14.400000000	105.511087000	105.509831000	10703.914100000	15.381000000
PAUSE				
14.999999760	112.169456000	103.948690000	10701.005800000	15.966000000
15.599999880	135.405234000	102.107258000	10735.904800000	16.539000000
16.200000000	116.523786000	105.819156000	12908.366300000	16.774000000
16.799999760	194.584530000	103.615915000	17934.982800000	17.203000000
17.399999880	227.688599000	102.508152000	24411.652000000	18.324000000
18.000000000	158.255314000	102.582971000	15527.534800000	19.336000000
18.599999760	160.838477000	102.511502000	15201.811000000	19.915000000
19.199999880	151.419321000	102.789560000	14751.032500000	20.581000000
19.800000000	105.008665000	104.894532000	11782.874200000	21.105000000
20.399999760	76.078763600	106.475774000	7588.598380000	21.280000000
20.999999880	68.844385200	106.881134000	6849.321640000	21.531000000
21.600000000	60.980709700	107.751041000	6677.153330000	21.660000000
22.199999760	53.195696400	107.692972000	5427.188180000	21.602000000
22.799999880	53.675281600	106.961536000	5141.598180000	21.613000000
23.400000000	53.462132700	107.399281000	5496.986140000	21.601000000
23.999999760	57.478976200	107.795709000	5903.559260000	21.677000000
24.599999880	57.902736700	107.742107000	6026.287340000	21.620000000
25.200000000	59.151180900	107.491967000	5898.324420000	21.533000000
25.799999760	57.938261600	107.326696000	5968.122380000	21.582000000
26.399999880	58.514271400	107.623737000	6090.850460000	21.440000000

CYCLE 3, B CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
27.000000000	64.358106300	106.811899000	6114.116450000	21.391000000
27.599999760	75.822477300	106.727030000	7413.521820000	21.577000000
28.199999880	51.716340900	107.268628000	5751.748700000	21.565000000
28.800000000	56.466518500	107.496434000	5527.813570000	21.547000000
29.399999760	56.354869000	107.392581000	5653.449900000	21.702000000
29.999999880	57.841837000	106.790682000	5399.850640000	21.730000000
30.600000000	55.136874800	107.571253000	5811.076960000	21.680000000
31.199999760	58.542183700	107.399281000	5718.013020000	21.707000000
31.799999880	56.149332500	107.459583000	5817.475110000	21.692000000
32.400000000	58.750257700	107.471867000	5805.260470000	21.733000000
32.999999760	57.689587700	109.364667000	6472.994300000	21.662000000
33.599999880	58.308734800	107.424965000	5826.199860000	21.636000000
34.200000000	57.258214800	107.763324000	5980.918670000	21.653000000
34.799999760	58.534571300	107.508718000	5872.150180000	21.597000000
35.399999880	57.121190400	107.589120000	5916.937200000	21.676000000
36.000000000	58.955794300	107.591353000	5877.385030000	21.722000000
36.599999760	59.562253900	107.218377000	5729.064360000	21.703000000
37.199999880	57.542413400	107.266395000	5775.596330000	21.772000000
37.800000000	57.755562400	107.493084000	5899.487710000	21.719000000
38.399999760	59.699278300	107.703023000	5961.142580000	21.594000000
38.999999880	56.469056000	107.761091000	6015.817650000	21.710000000
39.600000000	55.651984800	107.423849000	5716.268070000	21.749000000
40.199999760	6.287692380	109.106710000	911.841730000	21.713000000
40.799999880	5.633020460	111.054228000	1124.143860000	21.632000000
41.400000000	5.770044820	110.030218000	559.362025000	21.231000000
41.999999760	5.369121710	110.910174000	943.832462000	20.987000000
42.599999880	5.876619320	110.863273000	918.239876000	20.758000000
43.200000000	5.544208380	110.320559000	657.079171000	20.397000000
43.799999760	5.432558910	110.515980000	693.141451000	20.124000000
44.399999880	5.186422570	111.107829000	929.291220000	19.467000000
45.000000000	5.881694290	110.318325000	576.229866000	17.849000000
45.599999760	5.605108100	110.712519000	725.713833000	15.211000000
46.199999880	5.219409910	110.877790000	771.664157000	12.314000000
46.800000000	5.270159670	110.961542000	821.104380000	9.376500000
47.399999760	5.409721520	110.837589000	758.286215000	6.466000000
47.999999880	5.645707900	110.742670000	678.600209000	3.670800000
48.600000000	5.901994200	113.075448000	1534.788530000	1.582600000
49.199999760	5.607645580	111.002860000	728.040432000	1.081500000
49.799999880	5.280309630	111.145797000	777.480654000	1.062300000

STOP
.416 CP SECONDS EXECUTION TIME

CYCLE 3, B CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
0.000000000	2.184574210	101.909603000	2390.976860000	.315750000
.599976000	1.971425210	102.053657000	2471.826160000	.500190000
1.199988000	1.895300570	102.070407000	2475.316060000	.467560000
1.800000000	141.906279000	87.142412900	9944.279570000	.729230000
2.399976000	136.567404000	86.999475800	11328.024200000	2.037100000
2.999988000	120.581229000	88.618685200	10605.615300000	3.691000000
3.600000000	105.594825000	89.201600600	9808.755200000	4.978700000
4.199976000	95.741758500	90.360731300	9409.743520000	6.042700000
4.799988000	87.398497800	90.988314500	8935.117380000	6.920600000
5.400000000	80.653854600	91.255204900	8580.892730000	7.702300000
5.999976000	80.326518600	91.878321300	8380.805240000	8.371900000
6.599988000	73.670687500	91.483010900	7874.770020000	9.006200000
7.200000000	71.782796300	92.373017700	7914.903850000	9.529800000
7.799976000	71.572184800	92.256881300	7664.794490000	9.955500000
8.399988000	66.476908800	92.877764400	7601.976320000	10.403000000
9.000000000	63.612084800	93.149121600	7376.206250000	11.128000000
9.599976000	61.752106100	93.673968800	7432.134610000	11.633000000
10.199988000	61.026384500	93.163638600	7073.838410000	11.856000000
10.800000000	59.813465200	93.302109000	6983.682710000	12.113000000
11.399976000	104.077407000	88.710254300	9485.357980000	12.530000000
11.999988000	110.403364000	87.500872400	10562.573200000	13.005000000
12.600000000	113.874648000	86.335041600	10353.179300000	13.576000000
13.199976000	112.532317000	85.654973600	10217.654900000	14.168000000
13.799988000	106.460108000	86.592998400	10422.395600000	14.525000000
14.400000000	102.156528000	86.272506600	9724.415990000	15.087000000
PAUSE				
14.999976000	161.734210000	79.440559400	12482.598800000	15.740000000
15.599988000	180.544609000	76.201023800	14322.938300000	16.365000000
16.200000000	170.518994000	75.706327400	13476.056400000	17.061000000
16.799976000	237.110293000	67.507544200	15556.035700000	17.675000000
17.399988000	223.773255000	65.593526900	14710.317000000	18.163000000
18.000000000	213.547173000	64.080403600	13537.129600000	18.795000000
18.599976000	205.150631000	64.023452100	13328.317400000	19.454000000
19.199988000	197.967002000	63.379118400	12557.631600000	19.893000000
19.800000000	189.369992000	63.411502600	12370.922000000	20.332000000
20.399976000	183.764681000	62.927973200	11969.583700000	20.727000000
20.999988000	175.101697000	62.658849400	11409.455100000	21.083000000
21.600000000	110.969224000	73.441667600	9336.455660000	21.481000000
22.199976000	80.831478700	79.445026200	8206.891990000	21.715000000
22.799988000	56.565480500	84.266920300	6827.800600000	21.978000000
23.400000000	9.180428750	93.097753600	2941.799100000	22.257000000
23.999976000	9.685388870	95.019587700	2902.828580000	22.189000000
24.599988000	2.712371720	96.376373500	2901.083630000	21.950000000
25.200000000	6.450091620	96.783967600	3094.772970000	21.845000000
25.799976000	6.691152980	96.694631900	2644.576120000	21.848000000
26.399988000	3.521830410	92.244606200	2451.468430000	21.726000000

CYCLE N-1, B CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
27.000000000	7.551361430	98.245722900	3090.701420000	21.448000000
27.599976000	8.848017820	98.180954500	3023.811710000	21.348000000
28.199988000	4.919986320	97.723109100	2919.114770000	21.404000000
28.800000000	16.161058400	97.409317500	3586.266950000	21.193000000
29.399976000	18.465097500	96.705798900	3736.332560000	20.964000000
29.999988000	18.218961200	96.565095200	3784.609490000	20.950000000
30.600000000	18.470172500	97.520987100	4273.195220000	20.850000000
31.199976000	20.200739300	96.558395000	3864.295490000	20.793000000
31.799988000	11.811803900	96.596362700	4518.651380000	20.734000000
32.400000000	-7.391905680	96.278104200	5673.807640000	20.723000000
32.999976000	1.116291740	95.880560400	5350.410420000	20.721000000
33.599988000	-2.905626810	96.139633900	5637.745360000	20.712000000
34.200000000	-1.078635420	95.801275000	5509.200780000	20.919000000
34.799976000	-3.806435070	96.490276500	5718.594660000	20.787000000
35.399988000	-2.872639470	96.043598100	5645.306810000	20.687000000
36.000000000	-3.978984260	96.723666000	5805.260470000	20.631000000
36.599976000	.997029803	96.165317900	5449.290860000	20.579000000
37.199988000	25.788288000	96.463475800	4556.458610000	20.603000000
37.800000000	26.963145000	96.157501100	4350.554620000	20.731000000
38.399976000	25.620813800	96.534944400	4581.469550000	20.650000000
38.999988000	25.587826500	96.339522500	4348.228020000	20.659000000
39.600000000	24.887479800	96.636563700	4137.089190000	20.685000000
40.199976000	3.070157540	99.158063700	2571.288260000	20.616000000
40.799988000	1.090916860	100.756056000	2788.243590000	20.470000000
41.400000000	1.778576120	100.349578000	2537.552580000	20.396000000
PAUSE				
41.999976000	1.408102870	100.479115000	2560.236920000	20.372000000
42.599988000	1.248241120	100.565101000	2495.673800000	20.286000000
43.200000000	1.661851670	100.700221000	2569.543310000	20.022000000
43.799976000	1.793801050	100.310494000	2360.731080000	19.810000000
44.399988000	1.669464140	100.146340000	2257.197430000	19.743000000
45.000000000	1.819175930	100.368562000	2354.332930000	18.999000000
45.599976000	.837168056	101.485258000	2783.008740000	17.156000000
46.199988000	.936130090	101.505359000	2785.335340000	15.256000000
46.800000000	1.644089260	100.705805000	2414.242850000	13.458000000
47.399976000	1.694839020	100.993496000	2531.736080000	11.940000000
47.999988000	1.519752340	100.939194000	2481.132560000	10.266000000
48.600000000	2.453547940	100.515966000	2268.248780000	8.668600000
49.199976000	1.545127220	100.479115000	2207.175560000	7.858600000
49.799988000	2.128749470	101.009546000	2492.183900000	7.214200000
50.400000000	1.494377460	101.217251000	2513.704940000	6.683900000
50.999976000	1.600951960	101.184867000	2543.369080000	6.344000000
51.599988000	1.385150620	101.275320000	2550.348870000	6.165900000
52.200000000	1.737976310	101.266386000	2505.561850000	5.642700000
52.799976000	1.694839020	101.252986000	2511.378340000	4.186400000
53.399988000	1.496914950	101.296537000	2517.194840000	2.043700000

CYCLE N-1, B CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
0.000000000	1.256442280	110.422781000	967.394471000	2.529400000
.599999760	1.099118020	110.489783000	998.371256000	1.931200000
1.199999880	39.163976200	109.174873000	2656.505950000	1.840600000
1.800000000	242.736492000	97.241857700	17880.134500000	4.382100000
2.399999760	130.894169000	104.418306000	14392.031700000	6.290700000
2.999999880	134.428890000	105.511551000	13053.016300000	6.384600000
3.600000000	140.797985000	104.033045000	14890.582600000	7.824100000
4.199999760	216.777990000	102.423886000	18793.073600000	9.259700000
4.799999880	236.227835000	100.870562000	26077.293200000	10.629000000
5.400000000	201.786510000	101.765036000	21834.642600000	12.315000000
5.999999760	163.845989000	103.068220000	16921.607600000	14.212000000
6.599999880	113.459089000	104.140807000	13365.122000000	15.384000000
7.200000000	126.661639000	104.738797000	13238.877000000	16.039000000
7.799999760	129.366601000	102.468554000	12910.406200000	17.114000000
8.399999880	160.298581000	102.968834000	16066.531500000	17.913000000
9.000000000	182.811175000	101.672908000	18522.464500000	18.393000000
9.599999760	174.800325000	102.019084000	17757.980800000	19.347000000
10.199999880	161.067439000	102.741028000	17180.526800000	20.072000000
10.800000000	153.409301000	102.786813000	16260.574700000	20.754000000
11.399999760	155.733640000	102.915233000	16354.674000000	21.369000000
11.999999880	178.324896000	102.062635000	17505.490800000	22.127000000
12.600000000	186.244396000	101.101160000	19331.952200000	23.044000000
13.199999760	183.798257000	101.415510000	19097.580600000	23.668000000
13.799999880	176.259380000	101.842646000	18419.013700000	24.283000000
14.400000000	173.305744000	102.027459000	17677.324300000	25.009000000
14.999999760	156.532948000	103.083854000	16663.272900000	25.630000000
15.599999880	251.955186000	98.179882500	24544.234600000	26.309000000
16.200000000	309.495265000	97.387586600	30726.148800000	27.381000000
16.799999760	283.607812000	98.320027900	28674.082900000	28.405000000
17.399999880	265.198336000	98.562350900	26568.246000000	29.440000000
18.000000000	248.420465000	99.357438600	25219.294700000	30.412000000
18.599999760	235.918262000	99.450682700	23767.477100000	31.206000000
19.199999880	155.292117000	102.455712000	18511.359600000	31.924000000
19.800000000	44.875861800	106.616522000	5402.334920000	32.344000000
20.399999760	48.649106500	106.737684000	5540.269280000	32.384000000
20.999999880	48.570444400	106.476377000	5441.494250000	32.269000000
21.600000000	46.890627300	106.823669000	5604.560720000	32.131000000
22.199999760	47.989359600	106.848237000	5619.756880000	31.933000000
22.799999880	40.333758200	107.330649000	5138.740010000	31.583000000
23.400000000	56.378295100	106.703066000	5980.373410000	31.530000000
23.999999760	59.423280800	106.997315000	6940.069280000	31.498000000
24.599999880	63.643123400	106.262529000	7310.037290000	31.380000000
25.200000000	74.039211900	106.306639000	8405.914120000	31.232000000
25.799999760	91.900590300	105.315237000	10305.433900000	31.032000000
PAUSE				
26.399999880	106.280535000	104.514900000	11478.460500000	31.263000000

CYCLE 3, C CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
27.000000000	111.307299000	104.528859000	12038.965000000	31.519000000
27.599999760	113.248477000	104.208367000	11796.995400000	31.873000000
28.199999880	101.657232000	104.545051000	11275.065800000	32.121000000
28.800000000	76.853286200	105.770066000	8744.320880000	32.088000000
29.399999760	78.698040000	105.647788000	8689.380920000	31.984000000
29.999999880	82.636221400	105.524952000	8773.544260000	31.940000000
30.600000000	80.428606800	105.835951000	9001.486640000	32.098000000
31.199999760	79.388236700	105.778442000	8774.128730000	32.175000000
31.799999880	75.356168200	105.779000000	8462.607480000	32.311000000
32.400000000	75.262281200	105.867219000	8590.021420000	32.346000000
32.999999760	76.939560800	105.627688000	8437.475370000	32.375000000
33.599999880	76.947173200	105.613729000	8333.440130000	32.532000000
34.200000000	79.012688500	105.816968000	8466.114280000	32.564000000
34.799999760	79.002538500	105.727632000	8594.112700000	32.390000000
35.399999880	76.624912200	105.961580000	8619.829270000	32.385000000
36.000000000	76.635062200	105.548961000	8471.374490000	32.627000000
36.599999760	76.076814800	106.145835000	8531.574660000	32.517000000
37.199999880	55.665261000	106.845445000	7338.091740000	32.262000000
37.800000000	66.878420700	107.585814000	7729.685060000	32.142000000
38.399999760	57.593751900	106.604238000	7073.327900000	32.344000000
38.999999880	20.665688300	108.362477000	3128.755800000	32.422000000
39.600000000	1.147330300	109.317252000	1035.192720000	32.059000000
40.199999760	1.109267970	109.385929000	1036.946120000	31.810000000
40.799999880	1.048368260	109.641652000	1156.177520000	31.403000000
41.400000000	.733719744	109.527749000	1084.288000000	31.023000000
PAUSE				
41.999999760	.934181299	109.651144000	1117.602650000	30.965000000
42.599999880	1.035680820	109.508207000	953.951716000	30.642000000
43.200000000	.995021012	109.708654000	1034.608250000	30.224000000
43.799999760	.984931060	109.612618000	942.846830000	30.004000000
44.399999880	1.177780150	109.833724000	1083.703530000	29.648000000
45.000000000	.898656467	110.064321000	1211.117480000	29.397000000
45.599999760	.865669122	110.149190000	1254.952550000	29.142000000
46.199999880	1.236142380	109.706979000	928.819607000	29.007000000
46.800000000	1.322416970	109.945952000	1060.909290000	28.925000000
47.399999760	1.413766540	109.619318000	843.487332000	27.724000000
47.999939880	1.010305940	109.945393000	1007.138270000	25.432000000
48.600000000	1.289429630	110.050921000	1050.388880000	22.787000000
49.199999760	.992543524	109.913009000	998.955724000	20.124000000
49.799999820	1.043293290	110.200558000	1084.288000000	17.707000000
50.400000000	.845369218	110.170408000	1118.187120000	15.520000000
50.999999760	1.406154080	110.017420000	977.330421000	13.614000000
51.599999880	1.454366350	110.064880000	998.955724000	11.717000000
52.200000000	.639832686	110.229034000	1104.744370000	9.506300000
52.799999760	1.553328380	110.076047000	919.468125000	7.444300000
53.399999880	.776857040	110.251368000	1091.886080000	5.744700000

CYCLE 3, C CYCLE START/STOP

A

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
54.000000000	1.319879480	109.996761000	920.052593000	4.548600000
54.599999760	.969706132	110.208375000	1035.192720000	3.672000000
55.199999880	1.248829820	110.160916000	969.732342000	2.604300000
55.800000000	.723569791	110.229034000	1035.192720000	1.940800000
56.399999760	1.360479290	110.254160000	1025.256770000	1.886600000
56.999999880	1.233604890	110.300503000	1021.165490000	1.978100000

STOP
.486 CP SECONDS EXECUTION TIME

CYCLE 3, C CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
0.000000000	-2.351865720	104.086044000	2474.736510000	.997390000
.599976000	5.334185570	103.452877000	2532.014340000	.792310000
1.199988000	85.683744600	96.126233600	8643.792440000	1.061900000
1.800000000	240.759789000	84.163067500	17585.562900000	2.204800000
2.399976000	250.257607000	85.689591200	18592.016100000	4.153700000
2.999988000	178.248771000	86.196571200	16000.486600000	6.319000000
3.600000000	226.872117000	84.326105200	18023.329100000	7.875400000
4.199976000	198.348214000	85.839228500	17129.093600000	9.249700000
4.799988000	173.272757000	87.691827400	16270.510700000	10.579000000
5.400000000	169.151876000	88.481331600	15248.861200000	11.637000000
5.999976000	180.063075000	85.679540900	16365.194400000	12.701000000
6.599988000	241.429686000	83.404830800	19091.151500000	13.761000000
7.200000000	250.485981000	81.412644900	20851.568000000	14.882000000
7.799976000	229.767391000	82.521524100	19762.120300000	16.051000000
8.399988000	213.321931000	83.576802000	13827.556600000	17.147000000
9.000000000	204.651334000	84.113932900	17921.631700000	18.089000000
9.599976000	191.207722000	85.180377700	17290.406700000	18.960000000
10.199988000	182.552351000	85.781160300	16670.871000000	19.767000000
10.800000000	174.896749000	86.346208500	16200.374600000	20.472000000
11.399976000	167.038149000	86.741519000	15868.981400000	21.000000000
11.999988000	163.787627000	87.022926400	15151.839600000	21.653000000
12.600000000	155.439291000	87.701877700	14930.326400000	22.099000000
13.199976000	150.272965000	87.651626300	14422.424000000	22.608000000
13.799968000	146.646895000	88.455647600	14334.753800000	23.330000000
14.400000000	211.670026000	82.527107600	17864.938400000	23.833000000
PAUSE				
14.999976000	201.367825000	82.628727000	17730.510800000	24.349000000
15.599988000	193.770585000	83.259660300	17243.649300000	24.972000000
16.200000000	186.028709000	83.795674500	16735.746900000	25.564000000
16.799976000	179.847388000	84.771666900	16622.944700000	26.155000000
17.399988000	270.313912000	76.876625000	20767.989200000	26.612000000
18.000000000	284.447721000	74.110568600	21953.874000000	27.095000000
18.599976000	275.203652000	74.214421300	21342.520800000	27.812000000
19.199988000	267.428788000	74.077067700	20762.144500000	28.390000000
19.800000000	260.681608000	74.008949300	20192.873000000	28.970000000
20.399376000	254.649999000	73.788960100	19727.052300000	29.615000000
20.999988000	209.315237000	77.381371700	17686.675800000	30.109000000
21.600000000	137.187139000	85.761059700	13355.186100000	30.327000000
22.199976000	136.996828000	86.039117100	13267.515900000	30.563000000
22.799988000	136.740542000	86.001149400	13052.431800000	30.909000000
23.400000000	134.466952000	86.492495700	13081.655200000	31.111000000
23.999976000	132.617123000	86.739285600	12934.369400000	31.288000000
24.599988000	131.825427000	86.540513700	12786.499100000	31.482000000
25.200000000	130.820582000	86.503662700	12581.935400000	31.688000000
25.799976000	130.021273000	86.460111500	12483.160400000	32.000000000
26.399988000	128.432806000	86.566197700	12387.307700000	32.313000000

CYCLE N-1, C CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
27.000000000	62.064805800	93.879440900	8667.171150000	32.402000000
27.599976000	68.002527900	93.803505500	8245.769880000	32.389000000
28.199988000	68.256276700	93.985527000	8224.729150000	32.330000000
28.800000000	68.692724600	93.728686900	8238.171900000	32.289000000
29.399976000	70.151780200	93.921875300	8362.663510000	32.265000000
29.999988000	72.760317900	93.431645700	8231.742760000	32.515000000
30.600000000	85.457908100	93.491947300	8353.896500000	32.562000000
31.199976000	90.885595100	92.922432300	8377.859670000	32.350000000
31.799988000	62.749927600	93.730920300	8858.292070000	32.174000000
32.400000000	76.498037800	92.941416100	8789.909350000	32.079000000
32.999976000	65.782225800	92.588540100	9066.362550000	32.146000000
33.599988000	83.927802800	93.582399700	9014.344930000	32.066000000
34.200000000	75.249593700	93.069836200	9109.028690000	32.130000000
34.799976000	104.141433000	93.324442900	10419.405100000	31.830000000
35.399988000	120.495543000	92.415452200	12206.707200000	31.115000000
36.000000000	113.375352000	93.565649300	12593.624800000	30.863000000
36.599976000	112.279157000	93.523214800	12459.197200000	31.045000000
37.199988000	76.211301700	93.212773300	9020.774070000	31.659000000
37.800000000	64.320632700	95.478549800	8363.832450000	31.909000000
38.399976000	48.507007200	95.807975200	7036.506440000	31.777000000
38.999988000	-2.438140310	101.174817000	2660.597220000	32.012000000
39.600000000	-1.986467440	101.180400000	2229.844570000	32.153000000
40.199976000	-2.280816060	101.892853000	2456.618020000	31.918000000
40.799988000	-1.836755650	101.537743000	2234.520310000	31.595000000
41.400000000	-2.458440220	102.058124000	2456.033550000	31.443000000
PAUSE				
41.999976000	-1.775855930	101.851535000	2319.852590000	31.132000000
42.599988000	-2.529489880	102.403183000	2490.517140000	30.733000000
43.200000000	-2.341715770	102.165326000	2384.728500000	30.371000000
43.799976000	-2.268128620	101.886152000	2186.009500000	30.049000000
44.399988000	-1.849443090	102.160860000	2338.555550000	29.844000000
45.000000000	-2.171704070	102.118425000	2280.693260000	29.727000000
45.599976000	-2.133641750	102.122892000	2215.817350000	29.485000000
46.199988000	-2.565014720	102.531603000	2437.330580000	29.250000000
46.800000000	-2.293503500	102.269179000	2305.240900000	29.105000000
47.399976000	-2.384853070	102.671190000	2426.810170000	28.820000000
47.999988000	-2.278278570	102.572921000	2413.367410000	27.880000000
48.600000000	-2.136179240	102.250195000	2194.192050000	26.160000000
43.139976000	-2.118416820	102.593021000	2351.413840000	23.809000000
49.799388000	-1.877355460	102.457901000	2263.159230000	21.158000000
50.400000000	-2.567552200	102.656673000	2380.052760000	18.480000000
50.999976000	-1.857055550	102.599721000	2370.116810000	15.964000000
51.599988000	-2.557402250	102.824177000	2466.553970000	13.677000000
52.200000000	-2.166629090	102.713624000	2339.724490000	11.437000000
52.799976000	-2.613226090	103.040816000	2491.101610000	9.383200000
53.399988000	-2.222453830	102.677890000	2372.454680000	7.650700000

CYCLE N-1, C CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
54.000000000	-2.280816060	102.819710000	2396.417850000	6.372600000
54.599976000	-2.136179240	102.827527000	2398.171250000	5.487700000
55.199988000	-1.971242510	102.507035000	2273.095180000	4.857800000
55.800000000	-2.222453830	102.920213000	2448.435470000	4.189300000
56.399976000	-1.849443090	102.824177000	2318.899190000	3.285100000
56.999988000	-2.214841370	103.020649000	2442.006330000	2.128900000

STOP

.488 CP SECONDS EXECUTION TIME

CYCLE N-1, C CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
0.000000000	319.070771000	100.027970000	29765.267300000	2.791700000
.599999760	401.874081000	96.905687500	34030.504400000	5.995400000
1.199999880	422.171448000	96.343989300	38028.764300000	9.224300000
1.800000000	359.670579000	97.163644300	34021.198000000	12.070000000
2.399999760	281.696109000	99.122329400	28436.197800000	14.431000000
2.999999880	551.096140000	91.104450900	44107.003400000	16.555000000
3.600000000	359.421906000	97.221712500	38207.912400000	18.859000000
4.199999760	166.712376000	103.393692000	15501.472300000	20.652000000
4.799999880	193.883798000	102.520436000	19414.229600000	21.586000000
5.400000000	247.130447000	101.665047000	22406.235600000	22.442000000
5.999999760	183.802358000	102.747125000	18487.661700000	23.401000000
6.599999880	182.353452000	104.214464000	17360.424600000	24.255000000
7.200000000	264.446266000	100.312728000	23889.442300000	25.041000000
7.799999760	321.623484000	97.852645800	30990.803200000	26.097000000
8.399999880	293.302580000	98.923557500	28639.775200000	27.404000000
9.000000000	272.073955000	99.379169500	26580.735300000	28.501000000
9.599999760	254.410500000	100.136290000	25012.026100000	29.407000000
10.199999880	240.964351000	100.662253000	23675.976800000	30.359000000
10.800000000	228.936658000	101.268619000	22734.867700000	31.180000000
11.399999760	219.098817000	101.514293000	21675.101900000	31.953000000
11.999999880	210.588082000	101.705248000	20874.752000000	32.688000000
12.600000000	80.475844700	106.845400000	9542.471320000	33.120000000
13.199999760	93.691082400	105.754388000	9611.105980000	33.356000000
13.799999880	129.325027000	105.532165000	11420.618100000	33.337000000
14.400000000	201.983460000	102.364098000	19817.894500000	33.613000000
PAUSE				
14.999999760	254.042565000	100.445614000	22785.471200000	34.098000000
15.599999880	350.017975000	96.964872400	33081.833800000	34.809000000
16.200000000	339.530537000	97.298764500	32425.151300000	35.763000000
16.799999760	329.997194000	97.227296000	31411.917500000	36.728000000
17.399999880	320.684613000	98.062584700	30850.625600000	37.411000000
18.000000000	311.394869000	97.936398100	29886.832100000	38.112000000
18.599999760	302.620236000	98.477995700	29253.415600000	39.061000000
19.199999880	296.081129000	98.431094500	28408.278600000	39.988000000
19.800000000	288.494040000	98.944774700	27961.571700000	40.764000000
20.399999760	282.193457000	99.542207200	27578.846200000	41.319000000
20.999999880	275.963924000	99.506472900	26898.316000000	41.772000000
21.600000000	271.119859000	99.447288000	26283.512300000	42.172000000
22.199999760	265.805171000	99.541090500	25793.181700000	42.541000000
22.799999880	260.556296000	100.080455000	25508.173300000	43.184000000
23.400000000	256.257792000	99.864932300	24959.096000000	43.919000000
23.999999760	252.593659000	100.254659000	24686.302300000	44.329000000
24.599999880	249.043713000	100.357395000	24360.578500000	44.753000000
25.200000000	244.727446000	100.786207000	24165.144200000	45.175000000
25.799999760	242.458932000	100.429981000	23632.353100000	45.606000000
26.399999880	238.140127000	100.747122000	23396.203300000	46.109000000

CYCLE 3, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
27.000000000	236.188799000	100.724788000	23078.041000000	46.531000000
27.599999760	156.382262000	103.728701000	17199.889300000	46.776000000
28.199999880	111.910247000	105.125688000	11012.300100000	46.976000000
28.800000000	111.075413000	105.403745000	11026.841300000	47.158000000
29.399999760	110.847039000	105.745454000	11062.903600000	47.286000000
29.999999880	110.745540000	105.775605000	11130.956600000	47.297000000
30.600000000	110.915551000	105.703020000	11113.507100000	47.237000000
31.199999760	111.009438000	105.515415000	11002.412000000	47.455000000
31.799999880	110.029968000	105.923009000	11103.037400000	47.696000000
32.400000000	83.655317200	106.646628000	9057.957140000	47.724000000
32.999999760	42.695185200	108.202186000	4475.720980000	47.720000000
33.599999880	49.921951100	107.665055000	4559.478530000	47.538000000
34.200000000	45.610758900	108.502577000	4853.211620000	47.270000000
34.799999760	47.549399800	108.241270000	4899.743600000	47.023000000
35.399999880	50.289886900	108.310505000	4968.959910000	47.032000000
36.000000000	51.632218100	108.075999000	5466.852030000	46.922000000
36.599999760	59.818154500	108.039148000	5885.058150000	46.571000000
37.199999880	60.353564500	108.121784000	6429.482250000	46.365000000
37.800000000	66.978945800	107.873877000	6570.241470000	46.397000000
38.399999760	66.283674100	107.780075000	6791.268350000	46.474000000
38.999999880	79.430399600	107.181526000	7496.227760000	46.322000000
39.600000000	116.003215000	105.700787000	11496.232600000	46.261000000
40.199999760	115.995602000	105.133505000	11345.003700000	46.420000000
40.799999880	115.254656000	105.851541000	11567.193800000	46.536000000
41.400000000	114.318323000	105.918542000	11593.368100000	46.557000000
PAUSE				
41.999999760	113.975762000	105.825856000	11483.436300000	46.655000000
42.599999880	114.153386000	105.639368000	11373.504500000	46.818000000
43.200000000	113.775300000	105.649418000	11363.034800000	46.804000000
43.799999760	113.387065000	105.698553000	11363.616500000	46.681000000
44.399999880	112.760305000	105.840374000	11313.012900000	46.793000000
45.000000000	112.668956000	105.710837000	11294.981800000	47.073000000
45.599999760	112.077721000	105.660585000	11128.630000000	47.178000000
46.199999880	111.653960000	105.815806000	11193.193100000	47.196000000
46.800000000	112.062496000	105.775605000	11212.387500000	47.448000000
47.399999760	111.674260000	105.764438000	11233.908600000	47.556000000
47.999999880	111.334237000	105.804639000	11151.314300000	47.551000000
48.600000000	110.978989000	105.829207000	11153.059300000	47.504000000
49.199999760	111.014513000	105.641602000	11038.474300000	47.452000000
49.799999880	111.255575000	105.732054000	11055.342100000	47.490000000
50.400000000	110.583140000	105.575717000	10973.329500000	47.591000000
50.999999760	110.156842000	105.201792000	11063.485200000	47.721000000
51.599999880	110.337004000	105.442830000	10876.775700000	47.719000000
52.200000000	110.047730000	105.748804000	11032.076100000	47.759000000
52.799999760	110.227892000	105.447296000	10869.214200000	47.842000000
53.399999880	109.928468000	106.069296000	11094.894300000	47.883000000

CYCLE 3, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
54.000000000	110.164455000	105.730937000	10886.663700000	47.923000000
54.599999760	110.362379000	105.947576000	11091.986100000	47.869000000
55.199999880	110.298942000	105.586884000	10919.236100000	47.735000000
55.800000000	110.704940000	105.695203000	11043.127500000	47.702000000
56.399999760	110.468953000	105.948693000	11176.906900000	47.740000000
56.999999880	111.524548000	105.485264000	10977.982700000	47.754000000
57.600000000	111.143925000	105.756621000	11125.721700000	47.591000000
58.199999760	46.303493200	108.241270000	5723.359540000	47.505000000
58.799999880	61.503046600	108.243504000	6583.619410000	47.153000000
59.400000000	62.434304700	107.641604000	6365.500780000	46.893000000
59.999999760	63.631999000	107.714190000	6421.339150000	47.027000000
60.599999880	63.104201500	107.892861000	6571.986420000	46.749000000
61.200000000	63.365562800	107.411565000	6286.396430000	46.376000000
61.799999760	62.368330000	107.852660000	6498.116910000	46.162000000
62.399999880	63.454374900	107.561202000	6348.051290000	46.027000000
63.000000000	62.997627000	108.002297000	6637.131180000	45.759000000
63.599999760	63.170176200	107.931945000	6526.036090000	45.493000000
64.199999880	63.048376800	107.662822000	6419.594200000	45.377000000
64.800000000	64.720581400	107.642721000	6565.006620000	45.126000000
65.399999760	64.053222100	107.802409000	6747.644620000	44.948000000
65.999999880	69.219547700	107.832560000	7109.430720000	44.746000000
66.600000000	63.550799400	107.928595000	6749.971220000	44.697000000
67.199999760	47.379388100	108.549478000	5314.459820000	44.415000000
67.799999880	36.787913000	109.037475000	3962.124320000	44.098000000
68.400000000	37.313173000	109.091076000	4102.883540000	43.741000000
PAUSE				
68.999999760	33.722627400	109.392584000	3853.355830000	43.336000000
69.599999880	1.580266360	110.880023000	885.197521000	43.047000000
70.200000000	1.176805760	110.916874000	618.801969000	42.454000000
70.799999760	.940819368	111.003977000	643.812905000	41.922000000
71.399999880	1.334130020	110.932508000	558.310403000	41.563000000
72.000000000	.890069607	111.292084000	676.966937000	41.382000000
72.599999760	7.068853000	110.820838000	1161.481120000	40.778000000
73.199999880	40.335321300	109.405984000	3773.088170000	39.847000000
73.800000000	65.080904700	108.357407000	6762.767510000	39.772000000
74.399999760	68.427851500	108.272538000	7412.470200000	40.028000000
74.999999880	68.922661600	108.033565000	7340.345640000	40.052000000
75.600000000	69.577333500	108.042498000	7202.494670000	39.957000000
76.199999760	49.333253900	108.767234000	5783.269460000	39.708000000
76.799999880	49.906726200	108.877787000	5569.804020000	39.448000000
77.400000000	1.400184700	110.891190000	963.720228000	39.107000000
77.999999760	1.364579870	111.131280000	616.475370000	38.858000000
78.599999880	1.534591570	111.270867000	650.211052000	38.558000000
79.200000000	1.582803840	110.902357000	465.828184000	38.223000000
79.799999760	1.197105660	111.155847000	539.697613000	37.892000000
80.399999880	1.803565300	110.893424000	439.072219000	37.530000000

CYCLE 3, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
81.000000000	1.108293580	111.342336000	612.403823000	37.152000000
81.599999760	1.080381210	111.583542000	721.753962000	36.666000000
82.199999880	1.428017070	111.442838000	628.108364000	36.550000000
82.800000000	1.232630490	111.565675000	658.354147000	36.487000000
83.399999760	1.549816500	111.426088000	629.853313000	36.138000000
83.999999880	1.065156280	111.561208000	649.047752000	35.911000000
84.600000000	1.646241040	111.435021000	578.086492000	35.608000000
85.199999760	1.521904130	111.403754000	580.994740000	35.337000000
85.799999880	1.539666550	111.439488000	565.871848000	35.136000000
86.400000000	1.001719080	111.480806000	566.453498000	34.733000000
86.999999760	1.354429920	111.612576000	594.372683000	34.263000000
87.599999880	1.430554560	111.787897000	624.618466000	33.393000000
88.200000000	1.813715260	111.639377000	604.260727000	31.567000000
88.799999760	1.141280920	111.790131000	633.924861000	29.132000000
89.399999880	1.245317930	111.931951000	697.324675000	26.321000000
90.000000000	1.488916790	111.752163000	619.383619000	23.395000000
90.599999760	1.235167980	111.967685000	715.355815000	20.520000000
91.199999880	1.483841810	111.730946000	598.444230000	17.658000000
91.800000000	.953506808	112.012353000	768.285936000	14.811000000
92.399999760	1.372192340	111.764447000	632.179912000	12.225000000
92.999999880	.994106617	111.815815000	607.750625000	10.151000000
93.600000000	1.212330590	111.849316000	639.741357000	8.607900000
94.199999760	.819019942	111.952052000	699.651274000	7.278700000
94.799999880	1.212330590	111.813581000	624.036816000	5.955100000
95.400000000	1.242780450	111.786781000	587.392886000	4.562500000
95.999999760	1.268155330	112.010120000	649.047752000	2.627900000
96.599999880	1.382342290	111.997836000	651.956001000	1.373600000

STOP
.814 CP SECONDS EXECUTION TIME

CYCLE 3, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
0.000000000	-1.330232430	105.479681000	1360.986960000	1.516300000
.599976000	-.995284011	105.453997000	1355.752110000	.952220000
1.199988000	58.897046400	103.697434000	3334.524310000	.973030000
1.800000000	442.392690000	83.991096300	31655.628800000	2.169800000
2.399976000	463.496978000	80.480203500	34848.303800000	4.906100000
2.999988000	463.037693000	79.095500300	33060.312700000	7.916400000
3.600000000	401.130597000	80.685675600	31566.054700000	10.778000000
4.199976000	355.537011000	83.830292100	28532.170000000	13.177000000
4.799988000	417.215733000	79.981040400	31694.017600000	15.173000000
5.400000000	391.099906000	81.365743600	30973.935300000	17.003000000
5.999976000	367.272894000	82.414321300	29160.933300000	18.672000000
6.599988000	347.056726000	83.621469900	27878.977400000	20.065000000
7.200000000	327.683005000	84.856535800	26877.958300000	21.376000000
7.799976000	308.824394000	85.351232200	25922.889500000	22.618000000
8.399988000	298.400393000	85.825828100	24987.015200000	23.633000000
9.000000000	288.011917000	86.636549500	24317.536400000	24.614000000
9.599976000	274.464268000	87.112262100	23524.166300000	25.539000000
10.199988000	263.910856000	87.720861500	23047.213500000	26.383000000
10.800000000	259.990437000	87.991102000	22391.694300000	27.250000000
11.399976000	250.670243000	88.639902500	21927.537900000	28.089000000
11.999988000	240.822252000	89.142415700	21560.517000000	28.897000000
12.600000000	240.530441000	88.695737300	20928.263800000	29.629000000
13.199976000	235.569652000	89.621478400	20770.055000000	30.163000000
13.799988000	229.309669000	89.757715300	20317.531600000	30.807000000
14.400000000	221.730192000	89.920753000	20037.758100000	31.442000000
14.999976000	222.166640000	90.243478200	19773.689100000	31.852000000
15.599988000	214.023841000	90.476867700	19438.658900000	32.334000000
16.200000000	211.658902000	90.357381200	19126.313100000	32.889000000
16.799976000	210.671819000	91.203836900	19160.048700000	33.239000000
17.399988000	204.109875000	90.866594600	18730.791300000	33.679000000
18.000000000	205.335482000	90.594120700	18425.425200000	34.246000000
18.599976000	205.160395000	91.133485000	18417.282100000	34.596000000
19.199988000	198.093491000	90.953696900	17988.606300000	34.878000000
19.800000000	198.834437000	91.040799200	17865.878200000	35.485000000
20.399976000	253.694029000	88.065920600	21821.096000000	35.976000000
20.999988000	266.582830000	87.561174000	23485.777400000	36.252000000
21.600000000	261.160219000	87.436104000	22939.026700000	36.846000000
22.199976000	255.308771000	88.090487900	22734.867700000	37.519000000
22.799988000	250.157670000	87.985518500	22098.542900000	38.161000000
23.400000000	244.915220000	88.044703400	21636.131400000	38.822000000
23.999976000	240.434016000	88.432197000	21342.980000000	39.318000000
24.599988000	236.462847000	88.714721100	21165.576800000	39.717000000
25.200000000	232.857077000	88.992778400	20889.293200000	40.310000000
25.799976000	228.741271000	89.025162600	20501.332900000	40.979000000
PAUSE				
26.399988000	225.602399000	89.369105100	20364.645200000	41.509000000

CYCLE N-1, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
27.000000000	221.925578000	89.447273800	20051.136000000	41.999000000
27.599976000	218.789243000	89.649395800	19835.344000000	42.221000000
28.199988000	216.650141000	89.713047500	19550.917300000	42.459000000
28.800000000	213.445293000	90.138508700	19536.957700000	42.884000000
29.399976000	211.554865000	89.730914600	19053.025200000	43.153000000
29.999988000	208.753478000	90.362964600	19151.324000000	43.387000000
30.600000000	207.294422000	90.082673900	18801.170900000	43.667000000
31.199976000	204.269737000	90.342864100	18717.995000000	44.235000000
31.799988000	203.236979000	90.512601900	18527.213900000	44.514000000
32.400000000	201.777923000	90.256878500	18321.309900000	44.769000000
32.999976000	199.600759000	90.768325400	18359.117100000	45.158000000
33.599988000	197.991991000	90.788425900	18195.091900000	45.239000000
34.200000000	196.411136000	90.965980600	18140.998500000	45.568000000
34.799976000	195.198217000	90.825276900	17963.013700000	45.859000000
35.399988000	193.599599000	90.878878300	17821.672800000	45.988000000
36.000000000	191.945157000	91.197136700	17786.773900000	46.389000000
36.599976000	191.161073000	91.293172600	17779.794100000	46.822000000
37.199988000	190.914937000	90.961513800	17434.294100000	47.072000000
37.800000000	188.676872000	90.926896200	17351.699900000	47.292000000
38.399976000	161.525758000	92.747111000	16163.971300000	47.470000000
38.999988000	89.311378100	97.249629900	9202.787910000	47.653000000
39.600000000	89.034791900	97.660574100	9194.644810000	47.681000000
40.199976000	89.359590400	97.283130800	8963.729890000	47.682000000
40.799988000	88.704918400	97.943098200	9279.565670000	47.701000000
41.400000000	89.674238900	97.208312200	8857.869650000	47.637000000
PAUSE				
41.999976000	88.857167700	97.832545300	9213.839250000	47.745000000
42.599988000	89.268240800	97.153594000	8909.054820000	48.015000000
43.200000000	88.499381900	97.939748100	9238.268540000	47.978000000
43.799976000	89.346902900	97.364649600	8917.197920000	47.722000000
44.399988000	88.918067400	97.672857800	9116.703760000	47.577000000
45.000000000	88.907917500	97.667274300	9084.713030000	47.691000000
45.599976000	88.892692500	97.767776900	9115.540460000	47.935000000
46.199988000	89.379890300	97.440585000	8972.454640000	47.979000000
46.800000000	88.636406300	97.740976200	9149.857790000	47.908000000
47.399976000	88.699843500	97.892846900	9148.694490000	47.776000000
47.999988000	88.938367300	97.743209600	9066.100240000	47.751000000
48.600000000	89.176891200	97.421601100	8966.638140000	47.888000000
49.199976000	89.521989600	97.685141400	9079.478180000	47.849000000
49.799988000	89.225103500	97.804627900	9183.593470000	47.670000000
50.400000000	89.808725700	97.512053500	9069.590130000	47.569000000
50.999976000	89.757976000	97.844829000	9292.943610000	47.574000000
51.599988000	90.034562200	97.570121700	9162.654080000	47.598000000
52.200000000	90.440560300	97.451751900	9159.745830000	47.605000000
52.799976000	90.125911700	97.762193500	9302.250000000	47.551000000
53.399988000	90.100536900	97.496419800	9189.991620000	47.537000000

CYCLE N-1, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
54.000000000	90.285773500	97.852645800	9260.371230000	47.461000000
54.599976000	90.823721000	97.746559700	9348.781980000	47.143000000
55.199988000	91.237331500	97.381400100	9160.909130000	47.188000000
55.800000000	91.447943000	97.317748400	9177.195320000	47.287000000
56.399976000	91.432718100	97.565654900	9349.945280000	47.118000000
56.999988000	92.211726900	97.242929700	9185.920070000	46.875000000
57.600000000	92.095002500	97.315515000	9274.912470000	46.600000000
58.199976000	91.985890500	97.717525600	9471.518060000	46.567000000
58.799988000	92.300539000	97.423834500	9352.853530000	46.666000000
59.400000000	92.658324800	97.194911800	9282.473920000	46.692000000
59.999976000	92.561900300	97.527687300	9536.073170000	46.548000000
60.599988000	93.485545900	97.410434200	9480.816460000	46.509000000
61.200000000	94.117380400	97.215012300	9390.079110000	46.594000000
61.799976000	92.983123300	97.554488000	9504.082440000	46.440000000
62.399988000	93.754519600	97.624839800	9592.493190000	46.144000000
63.000000000	94.432029000	97.163644300	9443.590880000	46.116000000
63.599976000	94.662940400	97.113393000	9436.029430000	46.184000000
64.199988000	94.289929600	97.382516800	9562.247410000	45.989000000
64.800000000	94.868476900	97.220595800	9552.359370000	45.875000000
65.399976000	94.576665800	97.575705200	9709.404780000	45.785000000
65.999988000	94.893851800	97.569005000	9692.536940000	45.695000000
66.600000000	94.721302600	97.386983500	9668.689300000	45.672000000
67.199976000	95.474936500	97.185978200	9591.329890000	45.689000000
67.799988000	95.383587000	97.424951200	9743.140460000	45.694000000
68.400000000	95.987509100	97.397033800	9742.558810000	45.492000000
68.999976000	95.731222800	97.287597600	9740.232210000	45.464000000
69.599988000	96.210808100	97.298764500	9763.498200000	45.495000000
70.200000000	96.558443900	96.915737800	9591.329890000	45.319000000
70.799976000	96.170208300	97.255213400	9767.569750000	45.256000000
71.399988000	96.657406000	96.969339200	9680.903940000	45.260000000
72.000000000	96.730993100	97.392567000	9902.512470000	45.157000000
72.599976000	96.746218100	97.364649600	9871.103390000	45.111000000
73.199988000	97.139528700	96.931673100	9734.415710000	45.051000000
73.800000000	96.812192700	97.496419800	9979.290230000	45.095000000
74.399976000	97.471939600	97.056441500	9791.417380000	45.034000000
74.999988000	97.801813100	97.098875900	9853.653900000	44.867000000
75.600000000	97.728225900	96.972689300	9766.406450000	44.905000000
76.199976000	97.413577400	97.324448600	9939.156400000	44.844000000
76.799988000	97.593739100	97.067608400	9814.101720000	44.874000000
77.400000000	97.119228800	97.266380400	9911.237220000	44.918000000
77.999976000	97.422802300	97.057558200	9787.345840000	44.861000000
78.599988000	36.181453400	100.967111000	5799.555650000	44.340000000
79.200000000	-1.677868300	103.866055000	1512.797520000	44.868000000
79.799976000	-1.373369730	103.994475000	1455.795850000	44.309000000
PAUSE				
80.399988000	-.657798101	103.717534000	1306.311890000	43.705000000

CYCLE N-1, D CYCLE START/STOP

CYCLE TIME(SECS)	BAT. CURRENT(AMPS)	BAT. VOLTAGE(VOLTS)	AVG. POWER(WATTS)	VELOCITY(MPH)
81.000000000	-1.388594660	103.889505000	1369.130050000	43.471000000
81.599976000	-1.342919870	104.059243000	1416.825330000	43.770000000
82.199988000	-1.231270400	103.861588000	1254.545070000	43.590000000
82.800000000	-1.535768970	104.000058000	1319.108180000	43.096000000
83.399976000	-1.129770880	104.138529000	1356.915410000	42.998000000
83.999988000	-1.342919870	104.175380000	1359.242010000	42.662000000
84.600000000	-.794822456	103.787886000	1193.471850000	42.459000000
85.199976000	-.698397910	103.911839000	1230.115780000	42.428000000
85.799988000	-1.462181810	104.434453000	1473.826990000	42.207000000
86.400000000	-1.616968580	104.364101000	1400.539140000	41.810000000
86.999976000	-1.188133100	104.471304000	1399.957490000	41.288000000
87.599988000	-1.228732910	104.030209000	1199.288350000	41.082000000
88.200000000	-1.312470020	104.404302000	1396.467590000	40.761000000
88.799976000	-1.606818630	104.530489000	1414.498730000	40.551000000
89.399988000	-1.380982190	104.614241000	1455.214210000	39.859000000
90.000000000	-1.637268490	104.519322000	1440.672960000	37.711000000
90.599976000	-1.606818630	104.435570000	1382.508000000	34.571000000
91.199988000	-1.241420350	104.230098000	1328.996230000	30.835000000
91.800000000	-2.000129280	104.601957000	1493.603080000	27.076000000
92.399976000	-1.738768010	104.674543000	1477.316890000	23.087000000
92.999988000	-2.068641460	104.671193000	1462.194000000	18.956000000
93.600000000	-1.317544990	104.406536000	1324.924680000	14.863000000
94.199976000	-1.487556690	104.469071000	1390.069440000	11.104000000
94.799988000	-1.518006550	104.687943000	1447.652760000	8.056400000
95.400000000	-1.873254880	104.634342000	1379.599750000	5.395100000
95.999976000	-1.439344420	104.542773000	1335.976020000	4.421000000
96.599988000	-1.495169160	104.580740000	1372.038300000	3.338500000

STOP
.820 CP SECONDS EXECUTION TIME

CYCLE N-1, D CYCLE START/STOP

Maximum Acceleration Data

Acceleration to 24 km/h (15 mi/h) for GE-100
(Same for 0%, 40% and 80% discharge)

Time	Velocity		Acceleration	
Seconds	km/h	mi/h	km/h·sec	mi/h·sec
0.00	0.0	0.00	3.86	2.40
0.42	1.6	1.00	4.78	2.97
0.76	3.2	2.00	8.69	5.40
0.94	4.8	3.00	10.14	6.3
1.10	6.4	4.00	7.72	4.8
1.31	8.0	5.00	7.72	4.8
1.52	9.6	6.00	7.72	4.8
1.73	11.2	7.00	8.69	5.4
1.91	12.8	8.00	8.69	5.4
2.09	14.4	9.00	7.64	4.75
2.31	16.0	10.00	7.40	4.6
2.52	17.6	11.00	7.40	4.6
2.75	19.2	12.00	6.95	4.32
2.99	20.8	13.00	6.76	4.20
3.24	22.4	14.00	6.44	4.0
3.49	24.00	15.00	6.44	4.0

Maximum Acceleration Data

Acceleration from 24 km/h at Various States of Discharge for the GE-100

Velocity		0% Discharge		40% Discharge		80% Discharge	
km/h	mi/h	km/h sec	mi/h sec	km/h sec	mi/h sec	km/h sec	mi/h sec
24.0	15.0	6.44	4.00	6.44	4.00	6.44	4.00
32.2	20.0	5.89	3.66	4.88	3.03	3.86	2.40
40.2	25.0	5.02	3.12	4.26	2.65	2.19	1.36
48.3	30.0	4.35	2.70	3.89	2.42	1.85	1.15
56.3	35.0	2.80	1.74	2.95	1.83	1.61	1.00
64.4	40.0	2.03	1.26	2.11	1.31	0.85	0.53
72.4	45.0	1.26	0.78	1.59	0.99	0.74	0.46
80.5	50.0	0.77	0.48	0.74	0.46	0.64	0.40
88.5	55.0	0.31	0.19	0.18	0.11	0.0	0.0

0% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
1.20	3.50	0.00
1.80	5.26	8.38
2.40	6.42	5.53
3.00	7.27	4.03
3.60	7.41	.68
4.20	7.48	.33
4.80	7.67	.90
5.40	7.99	1.51
6.00	9.96	9.39
6.60	11.23	6.04
7.20	12.58	6.42
7.80	14.56	9.45
8.40	17.19	12.61
9.00	18.95	8.39
9.60	19.20	1.17
10.20	19.80	2.85
10.80	22.49	12.90
11.40	25.17	12.83
12.00	28.14	14.28
12.60	30.80	12.71
13.20	33.59	13.36
13.80	36.09	11.96
14.40	38.07	9.48
15.00	39.91	8.75
15.60	41.57	7.89
16.20	43.27	8.14
16.80	45.64	11.31
17.40	47.55	9.12
18.00	49.36	8.62
18.60	51.25	9.03
19.20	53.73	11.84
19.80	55.61	8.98
20.40	57.37	8.39
21.00	59.26	9.00
21.60	60.98	8.21
22.20	62.81	8.71
22.80	63.88	5.07
23.40	65.18	6.20
24.00	66.68	7.15
24.60	67.53	4.04
25.20	68.87	6.34
25.80	70.03	5.55
26.40	71.15	5.30
27.00	72.28	5.41
27.60	73.14	4.05
28.20	74.25	5.30
28.80	74.85	2.85
29.40	75.65	3.81
30.00	76.68	4.87

0% Discharge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
30.60	77.11	2.05
31.20	77.86	3.58
31.80	78.56	3.30
32.40	79.16	2.88
33.00	79.73	2.68
33.60	80.11	1.81
34.20	80.40	1.40
34.80	80.86	2.19
35.40	81.23	1.72
36.00	81.58	1.70
36.60	81.84	1.22
37.20	82.30	2.18
37.80	82.93	3.01
38.40	83.02	.39
39.00	82.25	-3.63
39.60	82.93	3.22
40.20	84.00	5.08
40.80	84.17	.81
41.40	84.95	1.82
42.00	84.75	.92
42.60	84.08	-3.16
43.20	85.41	6.31
43.80	85.40	-.04
44.40	86.11	3.40
45.00	86.00	-.52
45.60	86.10	.47
46.20	86.48	1.79
46.80	87.07	2.79
47.40	87.10	.15
48.00	87.49	1.87
48.60	87.78	1.36
49.20	88.58	3.81
49.80	89.60	4.85
50.40	89.41	-.88
51.00	89.46	.21
51.60	89.61	.73
52.20	89.91	1.39
52.80	90.31	1.93
53.40	89.57	-3.54
54.00	89.21	-1.70
54.60	89.29	.37
55.20	89.43	.67
55.80	89.92	2.36
56.40	89.86	-.29
57.00	89.60	-1.25
57.60	89.89	1.35
58.20	90.41	2.49
58.80	90.73	1.52
59.40	90.92	.90
60.00	90.91	-.06

0% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
60.60	90.60	-1.48
61.20	90.91	1.51
61.80	90.92	.04
62.40	91.28	1.70
63.00	91.24	-.21
63.60	91.12	-.54
64.20	92.38	5.98
64.80	93.07	3.31
65.40	93.02	-.27
66.00	93.69	3.21
66.60	92.99	-3.35
67.20	93.23	1.16
67.80	93.13	-.50
68.40	93.86	3.49
69.00	93.59	-1.27
69.60	93.03	-2.70
70.20	93.96	4.46
70.80	93.67	-1.38
71.40	93.70	.14
72.00	93.49	-1.03
72.60	93.43	-.27
73.20	93.27	-.74
73.80	93.85	2.75
74.40	94.01	.72
75.00	93.68	-1.54
75.60	93.25	-2.03
76.20	93.95	3.33
76.80	93.78	-.80
77.40	93.69	-.46
78.00	93.76	.35
78.60	94.33	2.71
79.20	94.13	-.97
79.80	94.60	2.24
80.40	94.53	-.33
81.00	93.92	-2.89
81.60	94.17	1.18
82.20	93.66	-2.43
82.80	93.88	1.05
83.40	94.41	2.51
84.00	94.38	-.11
84.60	95.08	3.33
85.20	95.90	3.86
85.80	96.15	1.20
86.40	96.35	.95
87.00	96.70	1.66
87.60	96.79	.44
88.20	95.84	-4.52
88.80	97.26	6.80
89.40	96.08	-5.65
90.00	97.45	6.54

0% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
90.60	97.28	-.84
91.20	97.20	-.38
91.80	96.11	-5.15
92.40	96.68	2.68
93.00	96.49	-.88
93.60	96.72	1.07
94.20	97.17	2.17
94.80	96.73	-2.11
95.40	97.55	3.88
96.00	96.38	-5.53
96.60	97.15	3.64
97.20	97.91	3.63
97.80	97.94	.11
98.40	98.52	2.76
99.00	97.03	-7.07
99.60	97.99	4.56
100.20	97.64	-1.65
100.80	98.54	4.25
101.40	98.71	.82
102.00	99.32	2.89
102.60	97.86	-6.95
103.20	98.03	.83
103.80	98.60	2.71
104.40	98.23	-1.77
105.00	99.63	6.69
105.60	98.62	-4.80
106.20	99.51	4.21
106.80	99.68	.79
107.40	98.62	-5.05
108.00	99.30	3.27
108.60	98.79	-2.43
109.20	98.27	-2.50
109.80	98.67	1.91
110.40	98.54	-.59
111.00	98.22	-1.52
111.60	98.21	-.08
112.20	98.74	2.55
112.80	97.86	-4.21
113.40	98.94	5.16
114.00	98.68	-1.26
114.60	99.56	4.20

40% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
1.20	3.50	0.00
1.80	8.20	22.93
2.40	13.44	25.67
3.00	18.56	25.09
3.60	22.98	21.49
4.20	27.07	19.77
4.80	30.16	14.87
5.40	33.28	14.95
6.00	35.82	12.16
6.60	38.96	15.08
7.20	42.49	17.03
7.80	46.01	16.92
8.40	48.26	10.77
9.00	50.70	11.68
9.60	52.83	10.17
10.20	54.73	9.06
10.80	56.76	9.69
11.40	58.36	7.62
12.00	59.70	6.38
12.60	61.29	7.58
13.20	62.70	6.70
13.80	64.43	8.26
14.40	65.56	5.34
15.00	66.78	5.83
15.60	67.75	4.62
16.20	68.76	4.82
16.80	69.55	3.73
17.40	70.36	3.87
18.00	71.37	4.79
18.60	72.06	3.26
19.20	72.70	3.04
19.80	73.33	2.99
20.40	74.25	4.37
21.00	74.71	2.20
21.60	75.36	3.10
22.20	75.44	.40
22.80	75.71	1.25
23.40	76.87	5.52
24.00	77.75	4.16
24.60	78.39	3.05
25.20	78.73	1.64
25.80	79.14	1.92
26.40	79.44	1.45
27.00	80.02	2.73
27.60	80.44	2.03
28.20	80.95	2.40
28.80	81.16	1.01
29.40	81.67	2.42
30.00	82.20	2.52

40% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
30.60	82.41	1.00
31.20	82.85	2.09
31.80	83.33	2.29
32.40	84.01	3.21
33.00	84.20	.93
33.60	84.75	2.59
34.20	84.74	-.04
34.80	85.51	3.68
35.40	86.02	2.42
36.00	86.30	1.32
36.60	86.32	.09
37.20	86.14	-.82
37.80	86.52	1.78
38.40	87.99	7.01
39.00	87.82	-.80
39.60	88.05	1.10
40.20	89.07	4.82
40.80	90.04	4.60
41.40	89.91	-.58
42.00	90.71	3.77
42.60	89.91	-3.80
43.20	90.04	.64
43.80	89.25	-3.76
44.40	89.83	2.73
45.00	90.12	1.39
45.60	90.89	3.68
46.20	91.23	1.60
46.80	91.38	.73
47.40	91.48	.45
48.00	91.75	1.28
48.60	92.31	2.68
49.20	92.26	-.21
49.80	92.62	1.69
50.40	92.57	-.25
51.00	92.73	.77
51.60	92.76	.17
52.20	92.95	.88
52.80	92.69	-1.21
53.40	93.34	3.08
54.00	93.11	-1.11
54.60	93.72	2.93
55.20	93.42	-1.47
55.80	93.09	-1.56
56.40	94.24	5.48
57.00	94.35	.51
57.60	93.88	-2.23
58.20	94.41	2.53
58.80	94.34	-.31
59.40	93.76	-2.77
60.00	94.30	2.57

40% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
60.60	94.50	.93
61.20	94.21	-1.39
61.80	94.42	1.00
62.40	94.79	1.75
63.00	95.02	1.09
63.60	94.70	-1.48
64.20	95.46	3.59
64.80	94.92	-2.55
65.40	94.73	-.90
66.00	96.33	7.62
66.60	96.18	-.74
67.20	95.49	-3.25
67.80	95.92	2.03
68.40	95.26	-3.15
69.00	95.80	2.56
69.60	96.17	1.77
70.20	96.18	.07
70.80	96.80	2.94
71.40	95.89	-4.34
72.00	96.65	3.64
72.60	97.33	3.22
73.20	96.38	-4.50
73.80	96.32	-.28
74.40	96.83	2.42
75.00	96.39	-2.10
75.60	97.14	3.55
76.20	96.98	-.77
76.80	96.90	-.39
77.40	97.20	1.45
78.00	97.75	2.60
78.60	97.02	-3.45
79.20	97.98	4.58
79.80	97.32	-3.17
80.40	98.42	5.26
81.00	98.23	-.92
81.60	99.10	4.13
82.20	97.61	-7.09
82.80	98.47	4.10
83.40	98.24	-1.11
84.00	98.08	-.75
84.60	98.17	.44
85.20	97.72	-2.12
85.80	98.58	4.08
86.40	98.28	-1.45
87.00	98.47	.94
87.60	97.82	-3.12
88.20	98.46	3.07
88.80	98.35	-.51
89.40	99.51	5.51
90.00	99.19	-1.53

40% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
90.60	99.39	.95
91.20	98.65	-3.51
91.80	98.76	.51
92.40	97.69	-5.11
93.00	98.11	2.01
93.60	98.10	-.03
94.20	98.92	3.87
94.80	97.72	-5.69
95.40	97.92	.92
96.00	97.80	-.56
96.60	98.00	.97
97.20	97.94	-.32
97.80	97.25	-3.26
98.40	97.53	1.32
99.00	97.08	-2.12
99.60	97.17	.41
100.20	97.43	1.24

80% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
1.20	3.50	0.00
1.80	3.87	1.73
2.40	7.60	18.04
3.00	12.74	25.18
3.60	17.61	23.75
4.20	22.38	23.27
4.80	26.65	20.72
5.40	31.30	22.65
6.00	35.53	20.53
6.60	38.72	15.32
7.20	42.00	15.76
7.80	45.09	14.82
8.40	48.07	14.33
9.00	50.85	13.31
9.60	53.32	11.83
10.20	55.76	11.67
10.80	57.90	10.21
11.40	59.34	6.84
12.00	61.13	8.56
12.60	62.78	7.85
13.20	64.11	6.31
13.80	65.68	7.49
14.40	67.14	6.97
15.00	68.16	4.82
15.60	69.34	5.64
16.20	70.27	4.42
16.80	71.30	4.87
17.40	72.26	4.58
18.00	73.38	5.32
18.60	74.40	4.83
19.20	75.46	5.04
19.80	76.31	4.04
20.40	76.47	.77
21.00	77.86	6.64
21.60	78.70	3.97
22.20	79.37	3.19
22.80	79.96	2.82
23.40	80.57	2.88
24.00	81.06	2.32
24.60	81.59	2.54
25.20	81.83	1.15
25.80	82.28	2.14
26.40	82.91	3.01
27.00	83.46	2.59
27.60	83.06	-1.88
28.20	84.09	4.86
28.80	84.68	2.84
29.40	84.37	-1.49
30.00	85.27	4.27

80% Disharge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
30.60	85.08	-.87
31.20	86.06	4.62
31.80	85.56	-2.35
32.40	85.95	1.85
33.00	86.99	4.96
33.60	87.22	1.07
34.20	86.93	-1.36
34.80	88.09	5.54
35.40	87.83	-1.27
36.00	88.08	1.21
36.60	88.54	2.18
37.20	88.21	-1.56
37.80	88.06	-.71
38.40	89.02	4.56
39.00	89.30	1.32
39.60	89.29	-.02
40.20	89.43	.63
40.80	89.78	1.69
41.40	90.22	2.08
42.00	90.02	-.94
42.60	90.09	.33
43.20	90.58	2.31
43.80	90.77	.92
44.40	90.06	-3.38
45.00	91.07	4.78
45.60	91.43	1.74
46.20	91.71	1.31
46.80	91.60	-.50
47.40	91.88	1.32
48.00	92.11	1.08
48.60	91.96	-.70
49.20	92.19	1.07
49.80	92.22	.15
50.40	92.93	3.40
51.00	93.11	.83
51.60	92.97	-.65
52.20	93.15	.84
52.80	93.49	1.63
53.40	93.74	1.16
54.00	93.74	0.00
54.60	93.80	.28
55.20	93.75	-.21
55.80	95.43	8.01
56.40	95.03	-1.90
57.00	94.17	-4.10
57.60	95.20	4.88
58.20	94.89	-1.43
58.80	94.30	-2.82
59.40	94.67	1.76
60.00	94.69	.10

80% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
60.60	95.78	5.15
61.20	95.58	-.91
61.80	95.40	-.86
62.40	95.35	-.23
63.00	97.09	8.28
63.60	95.88	-5.75
64.20	96.81	4.43
64.80	97.02	.99
65.40	95.68	-6.39
66.00	95.45	-1.09
66.60	96.16	3.38
67.20	95.77	-1.86
67.80	96.02	1.18
68.40	95.67	-1.65
69.00	96.24	2.71
69.60	95.43	-3.88
70.20	95.21	-1.03
70.80	96.03	3.92
71.40	95.94	-.42
72.00	95.44	-2.41
72.60	95.99	2.65
73.20	96.25	1.20
73.80	97.23	4.69
74.40	97.12	-.54
75.00	97.58	2.15
75.60	97.62	.23
76.20	97.22	-1.93
76.80	96.43	-3.73
77.40	97.20	3.66
78.00	97.66	2.15
78.60	96.96	-3.29
79.20	97.95	4.69
79.80	97.59	-1.70
80.40	97.63	.20
81.00	98.36	3.47
81.60	97.80	-2.68
82.20	99.68	8.98
82.80	98.11	-7.46
83.40	98.93	3.90
84.00	98.91	-.11
84.60	99.66	3.59
85.20	99.90	1.13
85.80	98.72	-5.[illegible]1
86.40	99.66	4.45
87.00	99.36	-1.42
87.60	99.04	-1.54
88.20	98.82	-1.05
88.80	99.24	2.03
89.40	98.90	-1.62
90.00	99.53	3.00

80% Dishcarge Gradeability at Speed

Elapsed Time (Sec)	Velocity (km/hr)	Grade (%)
90.60	99.20	-1.60
91.20	99.67	2.23
91.80	99.89	1.06
92.40	99.72	-.79
93.00	100.14	2.00
93.60	100.42	1.33
94.20	100.10	-1.52
94.80	100.30	.95
95.40	100.51	.97
96.00	100.12	-1.85
96.60	100.64	2.49
97.20	100.87	1.11
97.80	100.46	-1.98
98.40	100.12	-1.62
99.00	99.57	-2.61
99.60	99.84	1.30
100.20	99.21	-3.01
100.80	99.63	2.01

Cycle 1, Coast Down

ELAPSED TIME (SEC)	VELOCITY (KM/HR)	ROAD ENERGY (KWH/KM)	ROAD POWER (KW)	AVG. VEL. (KM/HR)
0.00	98.22	.0028	.2721	98.22
3.00	93.49	.2124	20.3609	95.85
6.00	90.57	.1315	12.1006	92.03
9.00	88.48	.0938	8.3987	89.52
12.00	84.04	.1997	17.2277	86.26
15.00	81.25	.1253	10.3530	82.64
18.00	78.09	.1421	11.3236	79.67
21.00	77.41	.0306	2.3783	77.75
24.00	74.50	.1305	9.9123	75.96
27.00	71.08	.1539	11.2037	72.79
30.00	69.02	.0925	6.4809	70.05
33.00	66.18	.1279	8.6444	67.60
36.00	63.86	.1043	6.7795	65.02
39.00	61.53	.1048	6.5673	62.69
42.00	59.28	.1009	6.0964	60.41
45.00	57.16	.0957	5.5728	58.22
48.00	54.85	.1038	5.8149	56.00
51.00	52.61	.1007	5.4104	53.73
54.00	49.76	.1278	6.5390	51.18
57.00	47.48	.1027	4.9913	48.62
60.00	45.28	.0990	4.5935	46.38
63.00	43.15	.0954	4.2195	44.22
66.00	41.33	.0821	3.4694	42.24
69.00	39.64	.0758	3.0696	40.48
72.00	38.21	.0643	2.5033	38.93
75.00	37.26	.0425	1.6034	37.74
78.00A	35.90	.0616	2.2521	36.58
81.00	34.85	.0468	1.6572	35.37
84.00	33.55	.0585	1.9994	34.20
87.00	32.49	.0480	1.5851	33.02
90.00	31.67	.0367	1.1782	32.08
93.00	30.51	.0519	1.6138	31.09
96.00	29.34	.0530	1.5850	29.92
99.00	28.37	.0432	1.2468	28.85
102.00	27.29	.0487	1.3542	27.83
105.00	26.32	.0439	1.1763	26.80
108.00	25.32	.0448	1.1579	25.82
111.00	24.16	.0520	1.2854	24.74
114.00	23.30	.0386	.9163	23.73
117.00	22.23	.0483	1.0989	22.77
120.00	21.37	.0387	.8428	21.80
123.00	20.30	.0481	1.0017	20.84
126.00	19.29	.0456	.9034	19.79
129.00	17.93	.0609	1.1339	18.61
132.00	16.83	.0493	.8562	17.38
135.00	15.69	.0515	.8370	16.26
138.00	14.57	.0502	.7599	15.13
141.00	13.44	.0507	.7106	14.01
144.00	12.49	.0427	.5535	12.97

ELAPSED TIME (SEC)	VELOCITY (KM/HR)	ROAD ENERGY (KWH/KM)	ROAD POWER (KW)	AVG. VEL. (KM/HR)
147.00	11.17	.0594	.7026	11.83
150.00	10.28	.0401	.4300	10.73
153.00	9.09	.0535	.5187	9.69
156.00	8.33	.0342	.2979	8.71
159.00	7.21	.0502	.3903	7.77
162.00	5.97	.0559	.3686	6.59
165.00	5.13	.0379	.2101	5.55

Cycle 4, Coast Down

ELAPSED TIME (SEC)	VELOCITY (KM/HR)	ROAD ENERGY (KWH/KM)	ROAD POWER (KW)	AVG. VEL. (KM/HR)
0.00	96.63	.1503	14.5732	96.96
3.00	92.07	.2050	19.3433	94.35
6.00	88.17	.1751	15.7784	90.12
9.00	85.12	.1373	11.8936	86.65
12.00	81.48	.1636	13.6292	83.30
15.00	79.14	.1050	8.4302	80.31
18.00	76.66	.1118	8.7118	77.90
21.00	74.24	.1087	8.1977	75.45
24.00	72.27	.0887	6.5000	73.25
27.00	68.88	.1520	10.7264	70.58
30.00	67.06	.0818	5.5618	67.97
33.00	64.16	.1306	8.5703	65.61
36.00	62.19	.0896	5.5951	63.17
39.00	60.66	.0689	4.2298	61.42
42.00	58.79	.0848	5.0147	59.72
45.00	56.94	.0832	4.8167	57.86
48.00	54.46	.1112	6.1957	55.70
51.00	52.80	.0749	4.0149	53.63
54.00	50.54	.1014	5.2408	51.67
57.00	49.13	.0634	3.1618	49.84
60.00	47.74	.0628	3.0401	48.43
63.00	45.70	.0913	4.2671	46.72
66.00	44.13	.0707	3.1764	44.92
69.00	42.63	.0675	2.9267	43.38
72.00	41.30	.0596	2.4998	41.97
75.00	39.75	.0697	2.8261	40.53
78.00	38.11	.0738	2.8742	38.93
81.00	36.98	.0508	1.9055	37.55
84.00	35.32	.0750	2.7092	36.15
87.00	34.18	.0508	1.7663	34.75
90.00	32.80	.0623	2.0865	33.49
93.00	31.37	.0644	2.0655	32.08
96.00	30.15	.0548	1.6561	30.76
99.00	28.60	.0695	2.0405	29.37
102.00	26.75	.0834	2.3077	27.67
105.00	24.60	.0963	2.4731	25.68
108.00	22.32	.1026	2.4069	23.46
111.00	19.95	.1066	2.2528	21.14
114.00	18.01	.0873	1.6572	18.98
117.00	15.94	.0930	1.5782	16.98
120.00	13.88	.0927	1.3823	14.91
123.00	11.87	.0904	1.1637	12.87
126.00	10.13	.0779	.8575	11.00
129.00	8.01	.0953	.8647	9.07
132.00	6.20	.0815	.5794	7.11

Cycle 7, Coast Down

ELAPSED TIME (SEC)	VELOCITY (KM/HR)	ROAD ENERGY (KWH/KM)	ROAD POWER (KW)	AVG. VEL. (KM/HR)
0.00	98.27	.1191	11.7368	98.54
3.00	94.10	.1878	18.0616	96.19
6.00	91.62	.1112	10.3290	92.86
9.00	87.84	.1700	15.2505	89.73
12.00	84.64	.1441	12.4280	86.24
15.00	83.02	.0726	6.0877	83.83
18.00	80.05	.1338	10.9054	81.53
21.00	77.42	.1180	9.2887	78.73
24.00	75.03	.1075	8.1942	76.23
27.00	72.43	.1168	8.6098	73.73
30.00	69.92	.1131	8.0490	71.18
33.00	67.99	.0865	5.9643	68.96
36.00	65.35	.1189	7.9283	66.67
39.00	63.24	.0948	6.0924	64.30
42.00	60.83	.1085	6.7299	62.03
45.00	58.07	.1242	7.3841	59.45
48.00	55.71	.1057	6.0154	56.89
51.00	54.04	.0751	4.1201	54.88
54.00	51.87	.0979	5.1848	52.95
57.00	49.75	.0952	4.8375	50.81
60.00	47.49	.1016	4.9394	48.62
63.00	45.41	.0934	4.3375	46.45
66.00	43.56	.0830	3.6915	44.49
69.00	41.60	.0885	3.7681	42.58
72.00	40.19	.0632	2.5836	40.89
75.00	38.96	.0552	2.1858	39.58
78.00	37.85	.0501	1.9259	38.40
81.00	36.63	.0548	2.0396	37.24
84.00	35.70	.0418	1.5130	36.16
87.00	34.43	.0571	2.0007	35.06
90.00	33.77	.0294	1.0029	34.10
93.00	32.83	.0423	1.4086	33.30
96.00	31.59	.0561	1.8069	32.21
99.00	30.69	.0403	1.2555	31.14
102.00	29.82	.0389	1.1769	30.26
105.00	28.90	.0414	1.2158	29.36
108.00	27.87	.0463	1.3135	28.39
111.00	26.99	.0397	1.0895	27.43
114.00	25.88	.0498	1.3168	26.44
117.00	24.90	.0441	1.1204	25.39
120.00	24.17	.0330	.8090	24.53
123.00	23.02	.0516	1.2172	23.59
126.00	21.73	.0581	1.2993	22.37
129.00	21.02	.0319	.6826	21.37
132.00	19.92	.0495	1.0126	20.47
135.00	18.66	[illegible]	1.0917	19.29
138.00	17.72	.0422	.7645	18.19
141.00	16.60	.0503	.8628	17.16
144.00	15.56	.0469	.7538	16.08

AD-A093 737 ARMY MOBILITY EQUIPMENT RESEARCH AND DEVELOPMENT COMM--ETC F/G 13/6
BASELINE TESTS OF THE GE-100 CENTENNIAL ELECTRIC PASSENGER VEHI--ETC(U)
SEP 80 E J DOWGIALLO, I R SNELLINGS EC-77-A-31-1042
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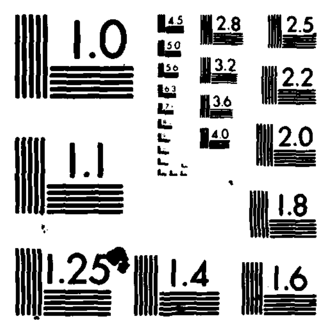

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ELAPSED TIME (SEC)	VELOCITY (KM/HR)	ROAD ENERGY (KWH/KM)	ROAD POWER (KW)	AVG. VEL. (KM/HR)
147.00	14.50	.0476	.7151	15.03
150.00	13.41	.0489	.6832	13.96
153.00	12.31	.0497	.6397	12.86
156.00	11.51	.0361	.4299	11.91
159.00	10.39	.0503	.5470	10.95
162.00	9.02	.0619	.6006	9.71
165.00	7.89	.0505	.4271	8.46
168.00	6.39	.0676	.4830	7.14
171.00	4.86	.0689	.3876	5.62

APPENDIX C

GRAPHICAL DERIVATION OF ROAD LOAD POWER

General

The acceleration and deceleration of the GE-100 electric vehicle can be determined using graphical methods. A Soltec model 3312 chart recorder was used to play back the velocity as a function of time. Tangents to the velocity curve were selected at increments of speed to reflect significant changes in acceleration. There is slow acceleration at zero speed with an increase in acceleration for about the first second. This can be attributed to the design characteristics of the controller which insure a smooth start, rather than a jerk, which might otherwise be associated with the maximum torque of a locked-rotor series d.c. motor.

Controller Effect

At about 4 seconds, under maximum acceleration, the vehicle has achieved sufficient speed for a bypass relay to shunt out the controller. Acceleration to about 24 km/h (15 mi/h) was independent of battery charge. The vehicle was accelerated under various states of battery charge, the effect of thermal cut back was noted on several runs. This is a controller feature which compensates for the temperature of the SCR. When the SCR warms up, it has a tendency to allow more current, a thermal sensor cuts back the condition time to retain the smooth starting characteristics. This test was run on a hot day 29°C (84°F) under stringent conditions (Electrolyte temperature reached 44°C (112°F)). The thermal sensor prevented operation of the bypass relay on several runs. If the thermal cut back had not operated, there would have been a noticeable jerk due to "torque jump."

Data Reduction

Newton's F = ma was used to determine the coast-down forces. Acceleration, a, was graphically determined by $\Delta V/\Delta t$ methods. The vehicle weight was taken as 1747 kg (3850 lb)* and the conversion factors were determined from:

* The original design weight of the vehicle was 1747 kg (3850 lb).

$$P = maV$$

$$m = W/g$$

W in pounds force
g in ft/s²
a in mi/h.s
V in mi/h
P in horsepower

$$P = \frac{W}{32.17} \times a\, \frac{5280}{3600} \times V\, \frac{5280}{3600} \times \frac{1}{550} \left[\frac{lb \cdot s^2}{ft} \cdot \frac{ft}{s^2} \cdot \frac{ft}{s} \cdot \frac{hp}{ft\ lb} \right]$$

$$P = W \times a \times V \times 1.216 \times 10^{-1}$$

The motor windage and friction were subtracted from the observed coast-down power to arrive at the vehicle external forces. The power was plotted as a function of velocity on log - log paper. Curve fitting resulted in the following empirical equation for vehicle power on zero grade:

$$P = 5.95 \times 10^{-2}\, V + 6.06 \times 10^{-4}\, V^2 + 1.05 \times 10^{-5}\, V^3$$

P in hp
V in km/h

Corrections

Motor windage losses were calculated from:

$$P_{windage} = 4.02 \times 10^{-3} \left(\frac{r/min}{1000} \right)^3$$

P in hp
r/min from mi/h x 80.5 motor/vehicle speed ratio.

Motor friction losses were calculated from:

$$P_{friction} = 1.327 \times 10^{-1} \left(\frac{r/min}{1000} \right)$$

and then corrected by 98 percent for drive train efficiency. Corrections to the power train loads for motor windage and friction were provided by the manufacturer.

Vehicle Road Energy

The energy consumption per unit distance as a function of speed was determined by converting the road load power from hp to kW and dividing by the velocity. This is the ERDA-EHV-TEP formula:

$$E = 9.07 \times 10^{-5} \, W \left(\frac{\Delta V}{\Delta t}\right) \frac{kWh}{mi}$$

Where $\frac{\Delta V}{\Delta t}$ = a in mi/h·s.

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